ERRC Publ. No. 3996

Proceedings

WHEY PRODUCTS CONFERENCE

held at Chicago, Illinois
September 18-19, 1974
and sponsored jointly by
The Whey Products Institute
and
The U.S. Department of Agriculture

AGRICULTURAL RESEARCH SERVICE • U.S. DEPARTMENT OF AGRICULTURE

Proceedings

WHEY PRODUCTS CONFERENCE/1974

held at

Chicago, Illinois

September 18-19, 1974

sponsored jointly by

WHEY PRODUCTS INSTITUTE
Chicago, IL 60606

and

U. S. DEPARTMENT OF AGRICULTURE
Agricultural Research Service
Eastern Regional Research Center
Philadelphia, PA 19118

Statements made in the papers are the speakers' own and do not necessarily represent the views of the U.S. Department of Agriculture. References, figures, and tables are reproduced essentially as they were supplied by the speakers. Numbers in parentheses refer to references at end of each paper. Mention of commercial products does not imply recommendation by the U.S. Department of Agriculture.

Additional copies of these proceedings are available from:

Eastern Regional Research Center
Agricultural Research Service
U. S. Department of Agriculture
600 East Mermaid Lane
Philadelphia, Pa. 19118

April 1975

PROGRAM AND CONTENTS

Wednesday Morning, September 18

Session Chairman: C. W. White
Purity Cheese Company

Wednesday Afternoon, September 18

Session Chairman: G. M. DeMedeiros
Dairymen's Cooperative Creamery Association

Thursday Morning, September 19

Session Chairman: D. H. Erickson
DMI, Inc.

WELCOMING REMARKS

D. J. PROCTOR

President, Whey Products Institute
Foremost Foods Co.
San Francisco, CA 94104

I. A. WOLFF

Director, Eastern Regional Research Center
Agricultural Research Service, USDA
Philadelphia, PA 19118

Mr. Proctor:

It is my personal pleasure to bid you a good morning and welcome to the Whey Products Conference 1974. We have been very excited about the opportunity for this kind of a program to bring several interests and disciplines together for a meeting of this type. And I think it will produce exceptional results.

As was mentioned, the conference is jointly sponsored by the Whey Products Institute in Chicago and the Eastern Regional Research Center in Philadelphia. In this conference we have a stated purpose. I would be certainly remiss if I did not talk about WPI's interest in that program, and I know Dr. Wolff will respond to the Eastern Regional Research Center's interest in this meeting.

We wanted to provide a forum where representatives of Governmental agencies, of our Whey Products Institute members, and other professions represented here could consider ways in which whey product utilization can be improved. We want to investigate while we are here and pursue, if you will, opportunities in research, processing technology, and indeed the utilization of these good nutritional products.

In my opinion, the change that this industry has undergone in the last few years has been very dramatic, and the future looks tremendously exciting.

I think I would certainly be remiss again if I did not mention the fine spirit of cooperation we have enjoyed between WPI and the Governmental agencies. Probably one of the best proofs of that is the relatively short period of time it took to develop our whey-soy beverage. This joint effort really started a relatively few months ago, and we are now very heavily engaged in that program of supplying the Government a very needed product in the AID program.

Having been in on those initial meetings personally, I have been tremendously gratified to see the way industry and Governmental agencies have been able to come together in a common effort and deliver an excellent product.

So again, when we consider utilization, we look forward to the tremendous opportunities we have for continued growth in this area.

The future of our whey industry in my opinion is a very dynamic one. We are finally coming to see the realization of goals that we had before us for some time--to make and be sure that people understand the relative values of the products we produce, the variations, and the fact that they can be used for either human consumption or for animal feed consumption.

If this turns out to be the good meeting we expect, it will not be the result of wishful thinking. An awful lot of time and effort by Jack Walsh, Dr. Wolff, Dr. Woychik, and their staffs has gone into the planning of this meeting to make it one that we can really enjoy.

It is indeed my pleasure to welcome you to this conference. I won't take any more of your time because we have a very full program, but I welcome you and ask you to please pay strict attention. Thank you, gentlemen.

Dr. Wolff:

Welcome to our third conference devoted solely to discussions on the most effective utilization of whey. Our Eastern Regional Research Center and its parent organizations, the Agricultural Research Service and the U.S. Department of Agriculture, are pleased to cosponsor meetings on such timely and important topics as this one. We fully anticipate that the discussions and interactions generated and catalyzed by our speakers will lead to fruitful results. I was most gratified in reviewing Mr. Walsh's remarks to the last Whey Products Conference, to be reminded that the origins of the Whey Products Institute can be traced to needs made evident by the first of these conferences, held in 1970. So our pleasure is even greater in working on this conference with an Institute which we had at least some small part in helping to create.

It is apparent from the attendance here today and from the interest it has elicited, that the Whey Conference has grown from an early enthusiastic beginning in 1970 to become the focal point for the meeting of university, Government, and industry leaders. As a result of these meetings, we have seen the development of a significant amount of cooperation and interchange of ideas between the various groups, which in addition to the associated technical presentations, has been one of the principal objectives set for these conferences. Further, we have seen the recognition of whey change from that of a pollution problem to that of a valuable byproduct of cheese manufacture. Now it forms the basis for an innovative, challenging, and profitable industry. This change could only have resulted from a coordinated, unified, cooperative effort which remains to be the requirement for continued future growth.

A few words regarding our dairy research program at the Eastern Regional Research Center may be appropriate here, especially since some changes have recently occurred. Dairy research in the Agricultural Research Service, oriented to products and processes, has in recent years been carried out in three locations--Washington, D.C., where emphasis was on dairy products; Beltsville, Maryland, where investigations were mostly directed toward cheese; and at our Center located in Wyndmoor, a suburb of Philadelphia, where most of the basic chemical and biochemical research was carried out. Now the units that were in Washington and Beltsville (except for research having a nutrition orientation) have for effectiveness and efficiency been moved to Wyndmoor. The centralized and unified group at ERRC is called the Dairy Laboratory, which includes the parts of the program moved in, as well as the group already stationed at the Center. The combination provides for effective and close relationships between scientists in basic and more applied research areas. The basic scientists can have a better feel for the mission-oriented implications of their work, while the applied effort can make basic researchers aware of developmental roadblocks they face. The group can also draw heavily on our excellent facilities, staff, and pilot plant at the Center.

We have every expectation of continuing and expanding the traditional strong role of leadership that USDA has enjoyed in the field of Dairy Research. This role goes back to humble beginnings in 1904 when the dairy research laboratories were based in a wooden structure in front of the USDA East Administration Building. Resulting from the work of that group, bound copies of research papers comprise 27 volumes and include reports on all important dairy technology problems since the turn of the century. To make the most of our strong new centralized dairy research group we urge those of you from industry and university to visit when you are in the area and interact with our scientists. You will always be welcome. We want our program to be as relevant and forward-looking as possible, with the results available and used.

I hope you'll forgive that obvious "commercial" which I considered so appropriate for a captive, dairy-oriented audience.

Since the last conference there have been significant developments in dairy and whey research at our Eastern Regional Research Center. Even though several will be discussed in detail in the program which follows, I would like briefly to mention some of these findings.

Our Center has been, and is still, actively engaged in a cooperative effort that can result in a substantial market for whey. The development I am referring to is the whey-soy beverage powder which is being offered as a substitute for nonfat dry milk in the Food for Peace and AID programs. Two research arms of USDA, the Agricultural Research Service and the Economic Research Service, together with AID, have been working closely with members of industry to develop detailed specifications for the blend. Through this cooperative effort, the time required to bring this product to its present state of development has been substantially shortened. Whey-soy blend purchases have been projected for up to 120 million pounds per year, reflecting the potential value of this product. You will be hearing more about whey-soy from Dr. Pallansch and Ms. Felton later in the program.

Another of our interesting developments is a new, simple method of making bread and rolls having the characteristics of San Francisco sourdough products. Our method does not require the use of or propagation of the sourdough starter. The distinctive taste of sourdough baked products is obtained by the substitution of acid whey and vinegar or acetic acid for the sourdough starter sponge. A number of advantages over the traditional method can be identified. For example, the whey provides additional nutrients such as milk proteins, minerals, vitamins, and sugars. The acid level of the product can be uniformly and reliably controlled. Of special significance to commercial bakers is the fact that it permits the use of regular baker's yeast. This provides a means for them to make sourdough baked products with the customary baking ingredients in existing equipment by standard procedures and at a fraction of the production time required by special yeast cultures. This translates to a materially lower production cost per unit. Definite commercial interest has been indicated.

Also developed has been a process for utilizing whole milk cheese set with acid whey for use in the manufacture of candy and hors d'oeuvres having higher nutritional values. The whole milk cheese, called "panir," used extensively in India and Pakistan, is made by direct acidulation of boiling milk. Various flavored candies containing panir centers were developed with 2 to 5 times the protein content of commercial candies, as well as higher levels of calcium and phosphorus.

Applications of lactase enzyme to the manufacture of a variety of dairy products, in addition to hydrolysis of lactose in whey, has received considerable effort. Pretreatment with lactase of milk intended for the manufacture of a variety of cultured products was found to have several beneficial effects. These ranged from shorter culture times to improved products yields. Work currently under way suggests a substantial reduction in the ripening times of cheddar cheeses made from lactase-hydrolyzed milks. In addition, the lactase-treated wheys obtained can offer advantages for certain specific end uses.

Finally, a continuous procedure has been worked out for the recovery of heat coagulable proteins from cottage cheese whey. Essentially all the heat coagulable protein, which is about 60% of the total protein content, is removed in a form in which the nutritional value is retained. Mr. Sinnamon of our Center will be relating the details of this work.

Our dairy program encompasses quite a scope of activities in whey research from which these and similar developments have been derived.

I'll mention some of these in case you may want to get details from some of our scientists. They include:

Oxidation of lactose to acidic disaccharide derivatives.

Fundamental and applied engineering research to increase the utilization of cheese whey solids.

Chemistry of the whey proteins as related to structural alteration during processing and their coprecipitation with the caseins.

Synthesis and evaluation of surfactants from whey.

Whey protein interactions using spectroscopic techniques.

Use of free and immobilized enzymes in whey utilization and cheese manufacture.

As we begin the technical portion of this conference, I hope that each of you will find your participation worthwhile and rewarding. On behalf of the Eastern Regional Research Center and the Agricultural Research Service, I would like to state that we are proud of our role in developing these conferences and will continue our active cosponsorship of future whey conferences.

FDA'S FOOD STANDARDS PROCEDURES

ROBERT W. WEIK

Food and Drug Administration
Washington, DC 20204

Your program committee has asked me to talk to you today on the subject "FDA's Food Standards Procedures" and to answer some of the "whys" that you have concerning these procedures. The purpose of and the procedures for establishing standards are set out in the Federal Food, Drug and Cosmetic Act. A standard may be proposed for establishment or amendment by any interested person. A "person" includes, among others, individual consumers or food processors or any association of consumers or food processors or the Commissioner of Food and Drug--for that matter, anyone. The next speaker on your program, Mr. Burditt, will consider with you what should be included in an industry petition or any other petition, and I will therefore defer any consideration of this topic during my remarks.

Section 401 of the Federal Food, Drug and Cosmetic Act provides the authority for the promulgation of definitions and standards of identity for foods. Our law requires that a food standard must be reasonable. This means, among other things, that the food is capable of being produced in accordance with good commercial practice or good manufacturing practice, but, and most importantly, a standard is established to promote honesty and fair dealing in the interest of consumers. I cannot over-emphasize this feature. The welfare of consumers is "the reason to be" for food standards.

Section 401 of the Federal Food, Drug and Cosmetic Act authorizes the Secretary, when such action will promote honesty and fair dealing in the interest of consumers, to promulgate a reasonable definition and standard of identity, a reasonable standard of quality and/or reasonable standard of fill of container. The standard of identity establishes the name of a food. It specifies what ingredients may be used. It further specifies whether or not there should be limitations on such ingredients. Finally, the standard of identity specifies what information must appear on the label and in what manner.

Standards of quality concern defects such as blemishes, color deviations, insect injuries, excessively hard products or excessively soft products, and other types of aesthetic defects. On some occasions they also set limits on safe bacteria loads. The third type of standard--that is a standard for fill of container--simply sets out requirements as to how much of a food or a component of a food must be in a particular type and style of container. This may be based upon volume, drained weight, or net weight. A number of criteria may be used for this third type of standard.

In accordance with the law and rules which have been set out, a "person" desirous of establishing a new, or amending an existing, standard must show that if the proposal is adopted it would be reasonable and would promote honesty and fair dealing in the interest of consumers. We consider such things as surveys of both consumers and processors, analytical studies, market studies, and so forth, in making the determination if the proposal is adequate. The proposal, if it is determined to be adequate, is published in the Federal Register.

Comments on the published proposal, in writing, are invited from all interested persons. All comments are evaluated and the Commissioner of Food and Drugs then publishes his order ruling on the proposal. All persons who claim to be adversely affected by the order are given 30 days to file objections. The objections must be specific, supported by data, and provide support for an alternative if one is proposed. The offer of simply increased competition is not acceptable as an "adverse effect." Further, the person objecting to an order and requesting a public hearing on the matter must be prepared to participate at such hearing personally or by means of a representative.

If objections are received which raise valid issues, then the Commissioner is required by law to conduct a public hearing to consider the issues. Based upon substantial evidence obtained at the hearing record, the Commissioner will affirm his earlier ruling or change it, in whole or in part. After this step, that is, following the conduct of the hearing and the publication of finding of facts, conclusion of law, and a final order based on the hearing record, any who now take exception to the Commissioner's decision may appeal to the Federal Courts for a judicial review of the matter and an appropriate decision is rendered.

Our procedure, although time-consuming and expensive, is one which provides a full test of each and every proposal and an opportunity to test the decision rendered. And, very important, all who are affected and who wish to participate may do so.

Our standards, once established, must be and are applied impartially not only to those foods produced by our own manufacturers but also to the foods of foreign manufacturers who export their products to us.

Food standards set at a reasonable level and properly enforced are important in a number of ways. They are important to consumers because they, the consumers, are assured of the identity, quality, and fill of container, as the case may be, including the safety and nutrition of the foods they buy. Further, consumers then have a reasonable assurance that the foods they purchase today will meet the same minimum standard tomorrow, next week, or next month unless these standards are changed. Processors of the food also benefit. Reasonable standards, properly enforced in an impartial manner, provide for fair competition.

I would like to spend the rest of my time on your program this morning to briefly consider a regulation concerning common or usual names for non-standardized foods and to discuss the FDA's philosophy toward imitation

foods. The common or usual name of a food may be established by regulation or by common or everyday usage. Foods for which there are standards of identity, of course, have prescribed names and these names must be used on the labels of the foods. The names to be used on nonstandardized foods have over the years mostly been decided by the seller of the foods. These names have in some instances been informative, in some instances not very informative, and in some other instances downright deceptive. In an effort to bring some order to this area, the FDA proposed in the Federal Register of June 22, 1972, a procedure for the establishment by regulation of common or usual names for nonstandardized foods.

After reviewing all of the comments received regarding this proposal, a final regulation was published in the Federal Register of March 14, 1973. This regulation sets forth the general principles for establishing common or usual names. These general principles stated that the common or usual name must accurately identify or describe in as simple and as direct terms as possible the basic nature of the food or its characterizing properties or ingredients. The regulation also said that the name shall be uniform among all identical or similar products and may not be confusingly similar to the name of any other food that is not reasonably covered under the same standard. Each class or subclass of food must be given its own name that states in clear terms what it is in a way that distinguishes it from other foods. These general principles also provided that where necessary to properly inform the consumer or to keep the consumer from being misled, the common or usual name would have to include the percentage of any characterizing ingredient or component or a statement as to the presence or absence of a characterizing ingredient or component. The regulation sets forth the manner and size for each statement to ensure that they all would be set forth uniformly and prominently. The regulation also sets forth the procedure for submitting petitions to establish such common or usual names. Mr. Burditt may have some comments on this procedure, because it is very similar to the 401 procedures.

We have already published several final regulations following these principles and we have proposed other regulations. In the future, we will be publishing a number of other such proposals both on our own initiative and on petitions from interested parties, such as the petitions submitted by the Whey Products Institute concerning the common or usual names for whey and whey derivatives.

The final regulations published to date include common or usual names for seafood cocktails and diluted orange juice beverages, both of which require the declaration of the percentages of characterizing ingredients as part of the common or usual names of these products. Other final regulations provide for the use of a statement showing that fruit- or vegetable-flavored noncarbonated beverage products containing no fruit or vegetable juice do in fact not contain any such juices. These are examples of names and requirements published under the common or usual name regulation.

Now let us consider imitation foods. As you know, in recent years the FDA's philosophy toward imitation foods has undergone a marked change. Our current thinking is that the word "imitation" in the name of a food is often not very informative and that this word should be reserved for products that

are clearly inferior in nutritive value to the product imitated. Let us very briefly consider some factors which have brought about this change.

A specific section of the Federal Food, Drug and Cosmetic Act, Section 403 (c), provides that a food shall be deemed to be misbranded if it is an imitation of another food unless its label bears in type of uniform size and prominence the word "imitation" and immediately thereafter the name of the food imitated. When this section of the Act was adopted in 1938 the Congress was seeking to protect the consumer from uninformed purchases of inferior substitute products which could be mistaken for a traditional food product.

Certainly, vast strides in food technology have taken place since 1938, and there are now on the market many new wholesome and nutritious food products, some of which resemble and/or are substitutes for other traditional foods. Significantly, it is no longer the case that such products are necessarily inferior to the traditional foods for which they may be substituted.

There has been some uncertainty as to the proper scope of the term "imitation" in this modern context. The term clearly fails to inform the public of the actual characteristics and properties of a new food product. To apply automatically the term "imitation" to new substitute food products which are not nutritionally inferior would be a disservice to consumers and would be contrary to the common understanding that the word "imitation" connotes inferiority. Also, to apply the term "imitation" automatically would present a serious obstacle to the development and marketing of modified products with improved nutritional content. Indeed, because of the traditional connotation of inferiority, application of the term "imitation" to a substitute food which is not inferior could, in itself, be misleading to the consumer, a violation of another part of the Federal Food, Drug and Cosmetic Act.

The consumer must be protected from the unwitting purchase of a product which is different from what he may reasonably expect, although not inferior. However, it is not the function of the Food and Drug Administration to attempt to arbitrate between the likes and dislikes of different individuals or between the different economic considerations that motivate various producers of agricultural commodities or manufacturers and distributors of food. The function of the Food and Drug Administration is solely to ensure the safety of all foods and to prevent misleading labelling. With this in mind, the Commissioner of Food and Drugs has concluded that it is in the interest of consumers and is consistent with the general intent of Congress to restrict the required use of the term "imitation" to a substitute food which is nutritionally inferior to the food for which it is a substitute.

The Commissioner recognizes that it is impossible to set out in general language in any regulation the precise parameters of nutritional inferiority. Accordingly, it must be recognized that the criteria for nutritional inferiority are not all inclusive and that the Commissioner has reserved the right to make a determination of nutritional inferiority on an ad hoc basis depending upon the facts of a specific situation.

Nutritional inferiority is not the only criteria involved in defining the imitation status. However, factors of comparison such as taste, texture,

origin, and cost are too subjective and uncertain for inclusion in a regulation. The Commissioner has concluded that the only objective factor that can be quantitated at this time relates to nutritional inferiority.

The regulation regarding the use of the term "imitation" is very specific and there is not sufficient time to discuss the regulation in detail. I would urge you to become familiar with the provisions of this regulation, particularly as it applies to the use of the common or usual names for foods you may now be, or may be thinking about, producing or manufacturing.

DEVELOPING INDUSTRY

PETITIONS/STANDARDS

G. M. BURDITT

Burditt and Calkins
Chicago, IL 60603

The preparation of a petition for a food standard is a very interesting assignment. It necessarily involves several different disciplines, including experts in different technologies, whose ideas and work product can perhaps best be set down in final form by a lawyer or other expert familiar with administrative procedures.

Section 401 of the Federal Food, Drug and Cosmetic Act authorizes the Secretary of HEW (who has delegated the authority to the Commissioner of Food and Drugs) to "promulgate regulations fixing and establishing for any food, under its common or usual name so far as practicable, a reasonable definition and standard of identity, a reasonable standard of quality and/or reasonable standards of fill of container." Before promulgating the standard, however, the Secretary must determine that such action "will promote honesty and fair dealing in the interest of consumers." Note that this requirement has both nutritional and economic ramifications. The proposed standard or proposed amendment to a standard might for example, authorize the use of ingredients less expensive than those customarily used in the food.

Regulations proposed by FDA appear in the daily Federal Register, and final regulations are codified in Title 21 of the Code of Federal Regulations. The sections with which we are particularly concerned are 21 CFR 10.2, Procedure for Establishing Food Standards, and 21 CFR 2.65, Procedure for Filing Petitions.

Section 10.2(a) provides:

> If the petitioner shows that he is an interested person and furnishes reasonable grounds for his proposal, it is the duty of the Commissioner to publish the proposal and afford opportunity for other interested persons to comment on it.

Note that this imposes two burdens on the petitioner: he must be an "interested person" and his petition must contain "reasonable grounds" for the proposal.

Section 10.2(a) continues:

> After a study of all the facts available and of the comments received, the Commissioner will act upon the proposal and publish an order, to which objection may be taken by persons who would be adversely affected. Thus the issues in controversy are singled out for a public hearing.

There is no time limit imposed on the Commissioner. During the considerable period of time that may elapse before the Commissioner acts, there may, of course, be negotiations between the petitioner and the appropriate officials at FDA.

Section 10.2(b) provides:

> Practical administration of the law requires that there be a substantial showing of merit before any proposal is published. In passing on proposals submitted by petitioners for initiating actions, it will be the policy of the Food and Drug Administration to consider that reasonable grounds have been furnished when:
>
> (1) The proposal includes or is accompanied by a statement of the facts that the petitioner asserts he is in a position to substantiate by evidence in the event the proceedings lead to a public hearing.
>
> (2) The facts declared furnish substantial support of the proposal and warrant a conclusion that the proposal is reasonable.
>
> (3) The proposal, if adopted, would promote honesty and fair dealing in the interest of consumers.

This section properly indicates that the Commissioner is going to consider a petition very carefully before publishing it as a proposal in the Federal Register.

There must be a "substantial showing of merit." This includes a complete statement of facts which the petitioner must indicate he is prepared to support with evidence if a hearing becomes necessary. The stated facts must also furnish "substantial" support of the proposal and warrant the conclusion that the proposal is reasonable. These are, of course, very general words but they serve as a broad guideline for the type of information which must be included in the petition.

Section 2.65 of the regulation states far more specifically the information which must be included in the petition. This regulation provides a form for a letter to be written to the Commissioner:

_____
(Date)

Commissioner of Food and Drugs
Department of Health, Education,
and Welfare
Washington, D. C. 20204

Dear Sir: The undersigned_____submits this petition pursuant to section 507(f) and section 701(e)(1)(B) of the Federal Food, Drug, and Cosmetic Act with respect to the issuance (amendment or repeal) of a regulation under _____(the blank to be filled in with the appropriate section of the Federal Food, Drug, and Cosmetic Act: sections 401, 403(j), 404(a), 406, 501 (b), 502(d), (h) or (n) or 507(f); or with section 5 of the Fair Packaging and Labeling Act or sections 2(q)(1)(B), or 3(a)(2) of the Federal Hazardous Substances Act).

Attached hereto, in quintuplicate and constituting a part of this petition, are the following:

(A) The proposed regulation in the form proposed by the petitioner.

(B) A statement of the grounds upon which the petitioner relies for the issuance (amendment or repeal) of the regulation. (Such grounds shall include a reasonably precise statement of the facts relied upon by the petitioner. If it appears that reasonable grounds for the action proposed are not stated in the petition, the petition will be denied.)

(C) If the petition seeks the amendment or repeal of an existing regulation, a reference to the section of Title 21, Chapter I, of the Code of Federal Regulations where it appears.

Very truly yours,

_____
(Petitioner)

Per _____
_____
(Indicate authority)

Mail Address _____

Section A of the letter must contain the exact wording of the proposed standard. Most standards consist of two basic parts: a "make-procedure" part describing the procedure for preparing the food. For example, 21 CFR 27.105, the standard for orange juice, provides that:

> (a) Orange juice is the unfermented juice obtained from mature oranges of the species Citrus sinensis. Seeds (except embryonic seeds and small fragments of seeds that cannot be separated by good manufacturing

> practice) and excess pulp are removed. The juice may be chilled, but it is not frozen.

The make-procedure provision of other standards is much longer and more complex, depending on the procedure by which the food is prepared. This includes such facts as the mandatory and optional ingredients and the percentage of each, the required percentage of fat, fruit, sugar, etc.

Some standards contain an "alternate make-procedure" provision which permits the use of methods not specifically described in the standard as long as the finished product is the same as the product produced by the specifically described procedure. For example, 21 CFR 19.500, the cheddar cheese standard, provides:

> (a) Cheddar cheese, cheese, is the food prepared from milk and other ingredients specified in this section, by the procedure set forth in paragraph (b) of this section, or by another procedure which produces a finished cheese having the same physical and chemical properties as the cheese produced when the procedure set forth in paragraph (b) of this section is used.

FDA has recently been authorizing the use of "safe and suitable" ingredients rather than specifying the particular ingredient which must be used. For example, the frozen raw breaded shrimp standard authorizes the use of "safe and suitable batter and breading ingredients."

The second part of a standard sets forth the required labeling, including the name of the food and the ingredients or other information which must be listed on the label. For example, the orange juice standard provides in 21 CFR Section 27.105:

> (b) The name of the food is "orange juice." The name "orange juice" may be preceded on the label by the varietal name of the oranges used, and if the oranges grew in a single State, the name of such State may be included in the name, as for example "California Valencia orange juice."

FDA has recently been requiring much longer terminology in the common or usual name. For example "orange juice drink containing ____% orange juice" is required by the proposed Section 27.158(d).

Some standards do not require a listing of ingredients on the label, on the theory that the ingredients are set forth in the standard itself. However since the standard is not readily available to consumers, there may be a trend requiring that all ingredients, both mandatory and optional, be listed on labels. In 21 CFR 3.88 is an FDA statement of policy which acknowledges the absence of legal authority to require that the labels of standardized foods bear complete information of the ingredients, but the section "encourages all manufacturers, packers and distributors to voluntarily make such disclosure.

Part B of the letter to the Commissioner must state the grounds on which the petitioner relies, including a reasonably precise statement of the facts. This is the full and technical part of the petition. It should give the complete story as to why the petition is being filed, how honesty and fair dealing are going to be promoted, and how consumers are going to benefit. This section may contain competitive data, historical data and all background information. It should include the technical and scientific background of the finished product and the ingredients, references to published literature and references to literature in the petitioner's files.

Part B should also include safety data, or a reference to safety data elsewhere filed or published. For example, a petition for an amendment to a food standard may be filed simultaneously with a petition for a food additives regulation, in which case the safety data is more appropriately set forth in the food additives petition, with a cross reference in the food standard petition.

Part B should also include a justification for the proposed name. The standards for several different types of orange juice products have raised substantial controversy within the industry, and between industry and FDA, as to what common or usual name should be required. FDA is tending to require additional information, such as a percentage of juice ingredients as a part of the common or usual name.

Let me turn now to procedures and timing, which are covered by Section 701(e) of the Federal Food, Drug and Cosmetic Act. After the petition is filed and considered by FDA, if FDA determines that it has merit, the proposal is published in the Federal Register. Comments are invited within a time period specified in the publication, customarily 30 or 60 days. After considering any comments received and making such changes in the proposal as it deems appropriate, FDA then publishes a final order in the Federal Register. The final order affords anyone who is adversely affected an opportunity to file objections and ask for a public hearing. The statute provides that "the filing of such objections shall operate to stay the effectivensss of those provisions of the order to which the objections are made." FDA then calls a hearing at which the proposal is discussed in detail, although FDA has been rather severely criticized in recent years for its failure to conduct hearings.

FDA's ruling must be based on substantial evidence in the record. It is not necessary that FDA's order be supported by a preponderance of the evidence, only substantial evidence.

If the petitioner is not satisfied with the final order he may appeal the case to the Court of Appeals, the Federal court immediately below the United States Supreme Court. Thus judicial review is provided to protect against administrative abuse.

States also have authority to promulgate standards under the model Food and Drug Act. Section 9 of this act includes an "automatic adoption" provision incorporating Federal Standards "now or hereafter adopted." The constitutionality of this provision has been questioned, but it has been affirmed, at least in Illinois, in an opinion issued by the Illinois Attorney General.

USDA SANITARY STANDARDS--

WHEY PLANTS

H. E. MEISTER

Agricultural Marketing Service, USDA
Washington, DC 20250

Recall with me if you will a bit of milk products history. Prior to World War II-some 30 or 40 years ago--a very large part of the milk produced in this Nation was separated on the farm. The cream was delivered to creameries for buttermaking and the skim milk was fed to livestock--calves, pigs and chickens. The skim milk was a good feed--the animals thrived on it. As you know, farmers and many consumers in those days considered skim milk essentially as an animal feed.

Dairy industry leaders began to see the potential for dried skim milk as an ingredient in bakery and other food products. But the long-entrenched stigma attached to skim milk as animal feed was a roadblock to the sale and use of this fine product for human food. So what happened? Members of the American Dry Milk Institute prevailed upon Congress to define the lowly dried skim milk with the name nonfat dry milk solids. Later the word solids was dropped to shorten the name, and so today dried skim milk is known as nonfat dry milk. Of course, times and tastes change. Diet-conscious consumers are big users of it, and they are very happy with a product once scorned. Its name is pasteurized skim milk, and it is a big seller.

Why all this preamble about skim milk when I'm supposed to be talking about whey? I simply use the historical situation with skim milk to draw a comparison. In the minds of many persons today, cheese whey continues to be an animal feed product. Some farmers and some cheese factory operators and their employees haven't really accepted the facts as they have been developing the past 5 years or so. Cheese whey is no longer a product to be disposed of as animal feed, or in old gravel pits, or on farm fields to avoid violating laws and regulations dealing with the pollution of lakes and streams.

Cheese whey over the years has gradually become established as a useful and valuable ingredient in foods. But it took the impact of a U.S. shortage of nonfat dry milk to put whey in its rightful position as a dairy food. Spurred by this shortage, nutritionists and members of the dairy and food industries have found that cheese whey is a fine alternate to all, or at least part, of the milk solids used in many foods.

This new and abundant source of protein and food nutrients is particularly important today with the world-wide shortage of protein foods for human food use. Modified whey has been accepted as an alternate to nonfat dry milk in corn-soya-milk, one of the products we are exporting under the AID programs, and whole whey is an important ingredient of the whey-soy drink mix which is also being exported in the U.S. program for feeding needy people overseas and about which we are hearing a great deal in this conference.

Yes, cheese whey is finally being recognized for its high nutritional quality, as an ingredient in foods. But waving a magic wand, or writing a government regulation, simply won't get the kind of sanitary practices and good whey processing and handling equipment that will yield a wholesome, good-quality whey product. To get top-quality human-food whey takes a lot of education on the part of cheesemakers and whey processors, and some investment in good equipment. It is our job, yours and mine in our industry/Government cooperative efforts, to see that whey is handled on a completely equal sanitary and quality footing with milk or cream.

But this job isn't necessarily as difficult or expensive as it might seem to be. In the first place whey is a byproduct of cheesemaking. And our cheesemakers have a fine record for making a wholesome, good-quality product. The key word I just used was "byproduct," and as far as cheese whey is concerned, the problem in many instances is its historic association with use of whey as animal feed.

What can be done to correct the situation? I've got a list of 6 items:

1. As a first step, the necessary sanitary facilities for handling whey must be provided in the cheese factory--pumps, pipelines, storage tanks, and heating and cooling equipment. And, of course, tank trucks like those used for hauling milk must be used for transporting whole or condensed whey to the processing plant.

2. USDA plant surveys show that in most cases the cheese factories and whey processing plants already have satisfactory equipment, so the outlay of new capital generally will not be very great.

3. The main problem that must be dealt with is training and supervision of plant workers to follow good practices for cleaning equipment in the whey handling department. The same methodical attention must be given to the daily cleaning of equipment for whey as is given to the equipment used in the milk-receiving and cheesemaking departments.

4. Another problem at the cheese factory is to develop and follow a system so that the whey is processed promptly after drawing from the cheese vats. If this is not possible, the whey should be cooled or heated to a sufficiently high temperature to control bacterial development pending further processing. Whey processors have much to gain from this kind of control and should provide leadership to cheesemakers on whey-handling procedures.

5. Still another problem is methodical movement of the whole or condensed whey from the cheese factory to the whey drying plant. It requires clean truck

tanks and it requires attention to see that plant storage tanks are emptied and washed before additional whey is placed in the tanks.

6. And finally, provision must be made for pasteurization of the whey at some time during the processing procedure.

Really, now, these six conditions and problems aren't all that difficult. They simply need our wholehearted attention. I mentioned USDA plant surveys or plant inspections. These voluntary inspections are a service of the AMS Dairy Division's Inspection and Grading Branch and can be an integral part of your action program for human food whey. Almost all of you in this audience--cheesemakers, whey processors, sellers, and distributors--are familiar with this service. Also you know plants that comply with the USDA inspection requirements are eligible for listing in the USDA Approved Dairy Plants booklet. This uniformly administered service is available Nationwide and is a very good way for dairy plants and their products to get favorable recognition.

Our USDA Regional supervisors and Washington staff are in close contact with the cheese industry, whey processors, and dairy equipment manufacturers to share professional expertise on sanitary design of dairy equipment. We work closely with the 3A Standards Committee whose objective is to assist dairy equipment manufacturers in their efforts to produce equipment that can be effectively cleaned and sanitized, and will not adversely affect the products. In recent years we have had the opportunity of working with the makers of reverse-osmosis and ultrafiltration equipment for whey processing, and they have been very cognizant of this need for sanitary design and use of materials that can be satisfactorily cleaned. We urge equipment manufacturers to use the services of the 3A Standards Committee, and we are convinced that buyers of dairy processing equipment would be well advised to look for the 3-A symbol of approval. In this connection we have seen one or two installations of fiber glass tanks in whey processing plants. We would respectfully advise that plant managers who are considering such tanks and the tank manufacturers put their questions to the 3A committee as to the suitability of this material for use with liquid dairy products.

The AMS Dairy Division, Standardization Branch, has underway a revision of the General Specifications for Dairy Plants Approved for USDA Inspection and Grading Service. In making this revision it is our aim to delete any material which is no longer applicable--and to update the requirements to bring them abreast of new technology in the processing and handling of whey and other manufactured dairy products. We invite you to give us your views and comments on an informal basis, either individually or through your trade association. Copies of the proposed revision are available from Whey Products Institute or from our office.

The Standardization Branch also is revising the U.S. Grade Standards for dry whey. We expect the standards will include a new classification system for whey based on 3 levels of acidity--(1) Sweet whey, (2) Medium acid whey, and (3) Acid whey. The range of acidity will be based on the acidity of whey from the different varieties of cheeses produced, and the acidity requirements for dry whey usage. Also, we are planning for two grade categories, U.S. Extra and U.S. Standard.

My main purpose here today has been to call your attention to the need for action to improve the image of whey so that it can stand shoulder to shoulder with other dairy products. This will require, in some cases at least, improvement in whey handling equipment and better sanitary practices. But perhaps more fundamentally it will require a better understanding by some cheesemakers and whey processors that whey is a valuable food product and must be handled under sanitary conditions equal to those used for other dairy products.

The Agricultural Marketing Act of 1946 requires the Secretary of Agriculture to provide technical information and services aimed at improving returns to farmers for agricultural products. This responsibility is assigned to USDA's Agricultural Marketing Service (AMS) which deals with aspects of marketing agricultural products such as inspection, grading, quality improvement and market news.

The Dairy Division of AMS is responsible to work with farmers, agricultural colleges, Federal and State regulatory agencies, and members of the dairy industry in the mutual interest of producing and handling milk and dairy products so they will be wholesome and of good quality, and give good satisfaction to consumers. The Division also administers the Nationwide market news service for dairy products.

BEYOND STANDARDS

OF IDENTITY

J. T. HUTTON

Foremost Foods Company
San Francisco, CA 94104

INTRODUCTION

A short time ago a picture and a caption appeared in Business Week. It attracted my attention. The picture was of Mills Lane, the former head of one of the South's largest banking businesses. The accompanying article commented on the circumstances surrounding Mr. Lane's retirement and reported some of the remarks he made as he stepped down from the bank's top position. The reasons used by Mr. Lane for early retirement included new computer techniques, new kinds of customers, new ways of making loans and financing them, and new money markets with which he was unfamiliar.

The caption was a quotation taken from Mr. Lane's remarks. It read, "I grew up with the adding machine, the times have passed me by."

To me, the caption is a clear reminder that time and the marketplace waits for no one. The cover feature of this week's Forbes magazine is a reminder that market obsolescence is a danger that knows no favorites. It is not confined to the banking business. The Forbes article concerns the academic community and examines the question of whether higher education is pricing itself out of the market.

The caption also reminded me of the whey industry. I recalled the first Whey Utilization Conference. There the industry reviewed its beginning, growth, size and new production techniques designed to advance the fight against pollution. But the requirements and realities of the marketplace went virtually unnoticed and untouched.

In addition, I was reminded of what one observer, unencumbered by our production logic and experienced in the field of marketing, said about the technics he found being practiced in the whey industry. Speaking at the annual meeting of the Whey Products Institute in 1972, Mr. Tom Drohan described what he saw as a three-pronged marketing plan. This sounded good, like a comprehensive marketing attack and like, as an industry, we knew where we were going. But, then he described the three. He called one the "spread-it-like-

manure plan," another the "quarry plan" and the third the "calibrated faucet system"--an ingenious arrangement using a calibrated drain valve to distribute evenly one load of liquid whey over an asphalt surface. If my recollection is correct, the key variable in the success of this plan was the time of night.

But most importantly, the caption reminded me that the whey industry has taken positive action to strengthen its marketing arm. To me, the program launched last year by the Whey Products Institute with the purpose of opening new marketing territory is a prime example of what needs to be and can be done. The plan was introduced by Mr. Don Proctor, now President of WPI. Its objective is to amend those food standards which bar whey products from large sectors of the food market. The legal and procedural phases of this program were discussed this morning by George Burditt and Dr. Robert Weik.

This afternoon I would like to look beyond the standards of identity themselves to examine where we stand now and what remains to be done after the regulatory barriers are lifted. In doing this, I would like to consider two points and raise one question.

1) Getting in step with time.

2) Markets ready for immediate entry.

3) What does whey have to offer?

GETTING IN STEP WITH TIME

The WPI food standards amendment program is a first step in a series of measures necessary to get the whey industry "in-step-with-time" as measured by the needs, wants and trends of the marketplace. It is a door opener and not an end in itself. Its basic value is that it gives the industry a needed sense of marketing awareness, purpose, and direction.

Historically, whey processors have operated on the assumption that what could be produced would be sold. The obvious result has been cyclic swings from "boom" to "bust." Past efforts to stabilize the business cycle have been further complicated by what might be called a sewer syndrome. It is the outgrowth of a constant urging to reach in and remove whey pollutants from the sewers of America. Technology to accomplish this has flowed from Government, university, and industrial laboratories. The industry now knows "101" ways to increase the supply in relation to demand. Mills Lane had money. We had whey. But he did not know how to market what he had to sell. And neither did we.

It has been said that a problem defined is half solved. Hopefully we are on the way to proving that this is so. Once we defined our marketing objectives and got started, we learned that a broad-based program to update FDA standards of identity was already underway. By cooperating and coordinating our efforts with those of the Bureau of Foods, we have been able to progress at a much faster rate than would otherwise have been possible.

The rationale behind and motivation for the ongoing FDA program is found in the 1969 White House Conference on Foods and Nutrition. Acting on the

findings and recommendations of the conference, FDA has now completed a series of actions designed to bring food standards of identity in step with the increasing demands of a growing number of Americans dependent on a finite food supply.

Introduction of the "safe and suitable" ingredient concept to replace the traditional "recipe-type" food standards was the final and basic change. In effect, this action removed a regulatory barrier and permitted wider, more effective use of whey and other sources of food energy.

Subsequent investigations such as the McGovern Senate Hearings in June of this year and a world conference just concluded in Bucharest have underscored the need for a new approach to the regulation and use of food supplies on an international as well as a national basis.

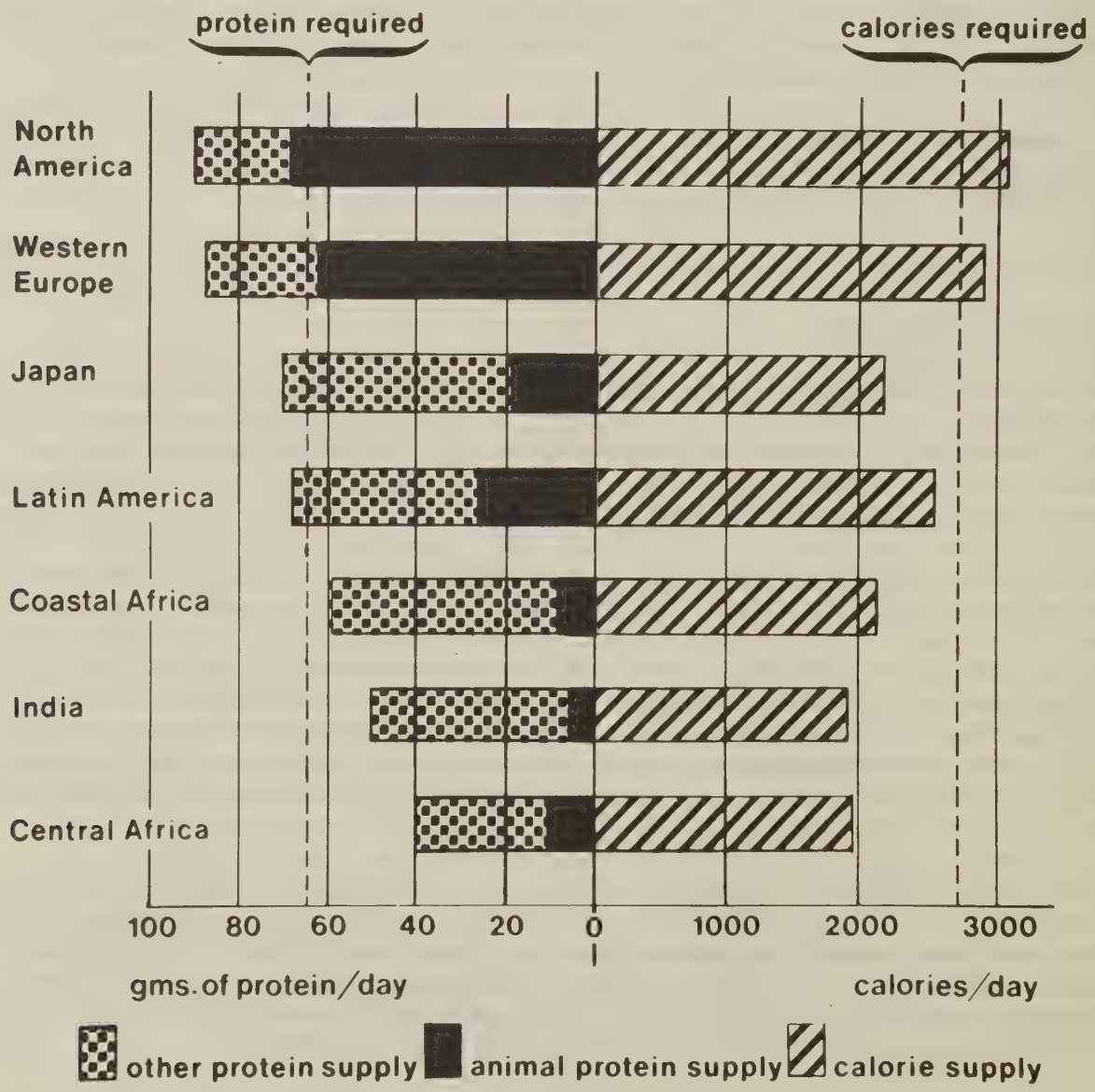


Figure 1.--Protein and caloric intake.

It is an accepted fact--by all but hard-core isolationists--that the United States is an intimate part of a world food system: consequently, an overview of the world food picture provides a useful insight as to the significance of what has been accomplished and what remains to be done.

The most pressing problem is food shortages which exist right now. The more basic problem is exponential population growth in a fixed space.

The immediate problem (Figure 1) is inequalities, or what some economists like to call dislocations, in food intake. The differences involve both protein and calories as well as differences in the quality of protein consumed (animal vs. vegetable). Most disturbing is the fact that large numbers of people are involved. The greatest shortages occur in the most densely populated regions of the world. At the Bucharest Conference, and elsewhere, the United States is presently being criticized for wasting far too much food energy in converting from wheat and other food grains to animal protein.

Assuming, on a world basis, we stay on our present population pathway, immediate solutions are neither available nor apparent. Even though the United States seems headed for zero population growth, the world is not. Before the end of this century we will need somehow to double the amount of food produced on a worldwide basis in 1967.

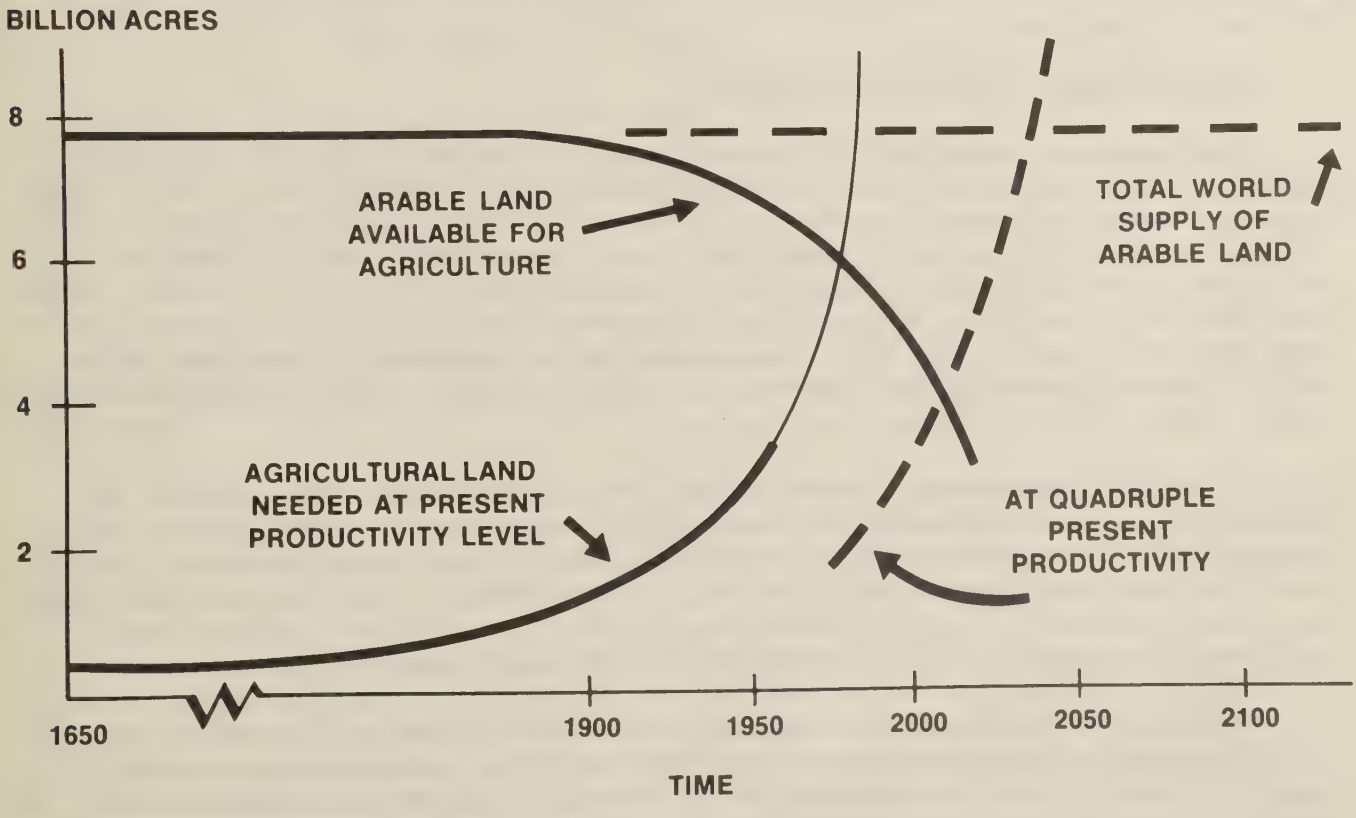


Figure 2.--Arable land available for agriculture and needed at present productivity level.

However this is accomplished, it will not be as simple as doubling the acreage of food crops. We simply don't have that much agricultural land to plant.

The world supply of arable land (Figure 2) is just under 8 billion acres. About half is already under cultivation while the remaining half is being depleted by such nonagricultural uses as cities, subdivisions, highways, and industry. Applied science and technology can be expected to increase agricultural productivity to some extent. Yet, it seems unreasonable to rely on new hybrids, better fertilizers, and improved farming technics for more than a delaying action. Even if agricultural output per acre could somehow be multiplied fourfold, we would delay by no more than 50 to 60 years what now appears to be an inevitable collision between a rising need for food and a declining per-capita production capacity. It is a bleak picture and one not shared by those who prefer to believe that problems ignored will go away.

Obviously, it was for good cause that the Food and Drug Administration accepted and acted to implement the recommendations of the 1969 White House Conference. It is not in itself a solution either here or abroad, but--it is a start in the right direction.

In sum, it seems fair to say that by integrating its food standards amendment program with that of the Food and Drug Administration, the whey industry has done much to "get in step" with our national food programs and with time.

Let's turn now to:

MARKETS READY FOR IMMEDIATE ENTRY

This morning George Burditt summarized the status of the WPI standards program. You will recall that the main thrust of the program to date has been to qualify whey and whey products as safe and suitable food ingredients. To accomplish this WPI has petitioned FDA for a lactose standard of identity and for "common and usual name" approval of whey and modified whey products. With FDA assurance that these approvals will become final in the near future, it is time that we examine all food standards which have been in recent months, or are in the process of being, amended to permit the use of food ingredients such as whey, modified whey, and lactose.

A total of 6 new markets are now ready for immediate entry. These are for the use of whey and modified whey in (1) margarine; and for the use of lactose in (2) canned corn, (3) grapefruit, and (4) applesauce, in (5) frozen peas, and in (6) fruit butter, jellies, and preserves. Final amendment action has been completed for all of these except the fruit butter, jellies, and preserves. Amendment of this standard will become final on October 29.

Foods whose standards of identity are in the process of amendment are listed under the heading "proposed." These include canned beans, canned tomatoes, table syrup, soda water, a series of 10 canned fruits (peaches, prunes, figs, apricots, pears, berries, pineapple and juice, cherries, seedless grapes, and fruit cocktail), and frozen desserts. All of these standards are for lactose, except for the frozen desserts, which call for whey or modified whey.

What about the size of these new markets? Are they large enough to merit attention or too small to count?

Let's, for the moment, set aside the question of margarine. Mr. Wiedermann will be talking to us about the utilization of whey products in his industry tomorrow morning. We are all familiar with the frozen dessert market. It consumes substantial quantities of whey products at the present time even though whey is limited to 25 percent of the nonfat solids. The proposed changes will remove this ceiling in both ice cream and mellorine. It seems reasonable to expect a substantial increase in whey utilization when the proposed amendment becomes final. The remaining 19 standards concern food products which use various nutritive carbohydrate sweeteners as ingredients. In other words, they represent new market opportunities for lactose.

The carbohydrate or nutritive sweetener market is new to most of us. To get our bearings we might first consider the annual U.S. consumption of the major sugars:

Type	Pounds (Million)	Per Capita (Pound)
Cane Sugar	14,750	72
Beet Sugar	6,450	30
Corn Syrup	3,500	16
Corn Sugar	1,290	5
Other	400	2
TOTAL	26,390	125

The total market is large, consuming over 26 billion pounds of nutritive sweeteners annually, and representing a per-capita consumption of about 125 pounds.

Let's break this total down. For our purposes I have selected four market categories [shown on the next page], which together consume just under seven billion pounds of nutritive sweeteners annually. The market categories and consumption figures are those reported by the census of manufacturers.

The first three of these categories represent foods for which standards of identity have been, or are now in the process of being, amended. Nearly 4 billion pounds of carbohydrate is used in these three areas. The fourth category (pickles, sauces, and salad dressing), which consumes approximately 3 billion pounds of sweetener per year, is one of the targets of the current WPI standards amendment program. Using these figures and similar market data for related food categories, we find that more than 10 billion pounds of carbohydrate sweetener is sold annually for use in standardized foods. I think

Market	Annual Consumption (Million Pounds)
Soft Drinks	2,800
Canned Fruits & Vegetables Jams, Jellies & Preserves	1,000
Frozen Fruits & Vegetables	160
Pickles, Sauces & Salad Dressings	3,000
TOTAL	6,960

it is reasonable to conclude that this volume is large enough to justify a major market development effort by the whey industry.

This brings us to the question:

WHAT DOES WHEY HAVE TO OFFER?

We need answers to this question if we are to penetrate these new markets in a meaningful way. We need good answers. We need persuasive answers based on solid technical and consumer acceptance data.

In some cases we have the answers and all that remains is to communicate the advantages and benefits of whey effectively. For other markets, for other products, and when competing against unfamiliar competition we will, I'm sure, find that we have some homework to do.

We know, for instance, that whey and modified whey products are an acceptable substitute for nonfat dry milk in an increasing number of foods. We know too that whey protein has some unique functional and nutritional properties. We know that it remains soluble in acid solution and that under the right conditions it will whip and jell. We know it has a high PER, falling within the range of 3-3.4 depending upon a number of things, such as the process used to separate it from whey. We know that whey protein provides a dramatic boost to the nutritive value of cereal protein as shown by Figure 3.

In addition, we know that whey protein has a similar effect on soy protein even when mixed in ratios as low as 1:9, as shown by Figure 4. This property is one used to good advantage in the whey-soy drink program which will be discussed tomorrow.

Let's look at lactose. What does it have to offer? It is by far the major ingredient of whey and for each pound of protein we market we have to sell about 8 pounds of lactose to somebody, somewhere. Perhaps one measure of where we stand is that, to the best of my knowledge, no one has come to us

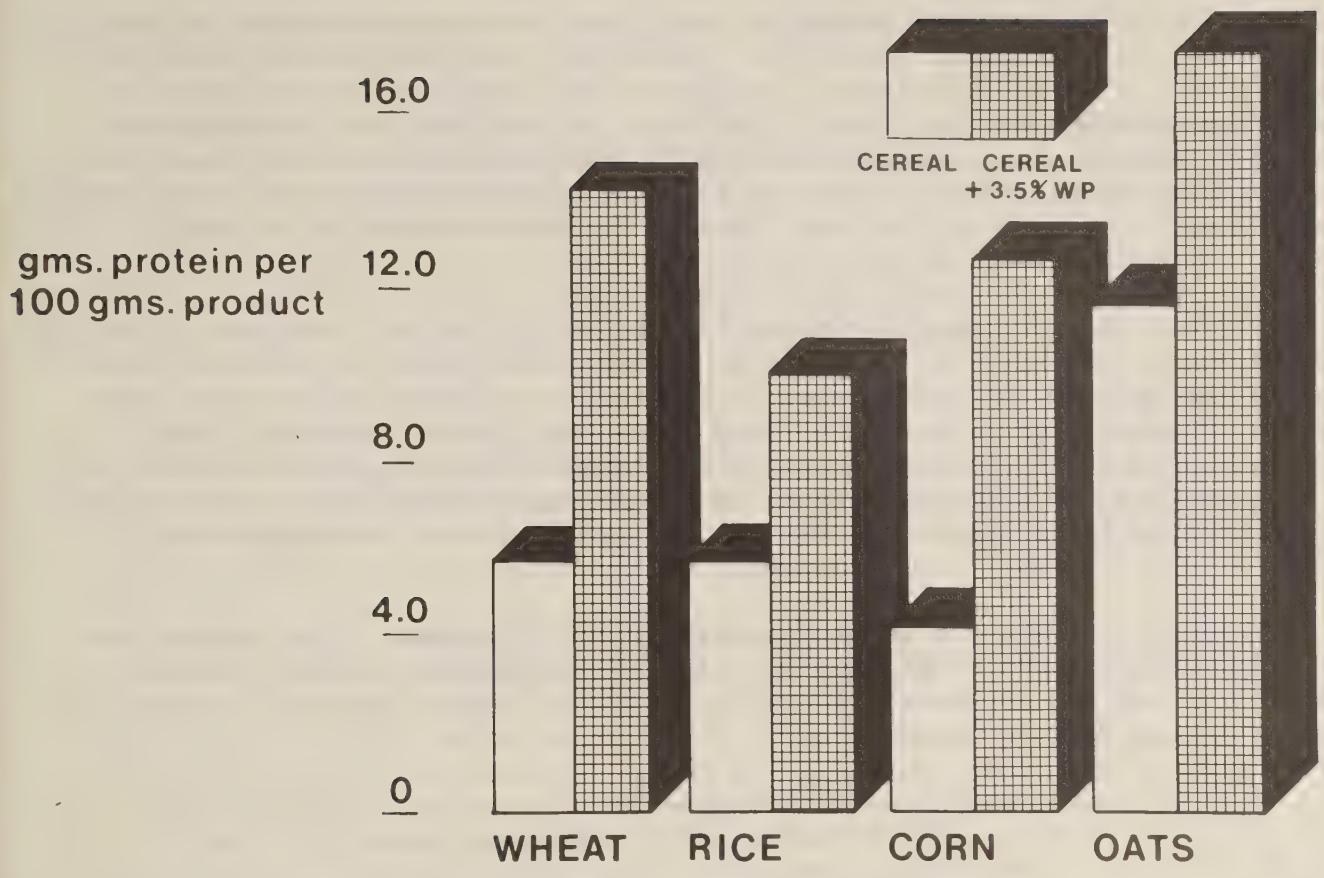


Figure 3.--Effect on balanced protein (FAO) of supplementing cereals with 3.5 percent whey protein.

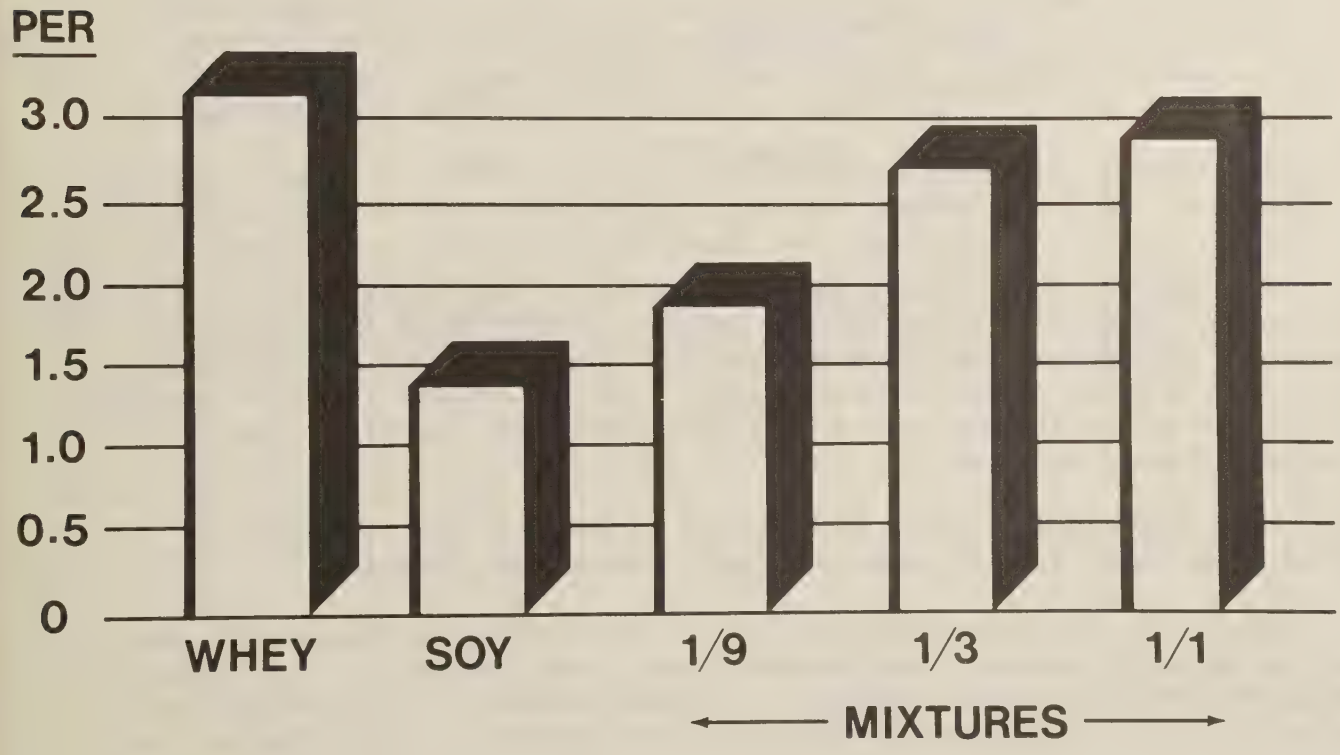


Figure 4.--PER values for whey and soy proteins and mixtures of these proteins in different proportions.

from any of the new markets where lactose is now an accepted ingredient for test, pilot, or production quantities. Does this mean that lactose is without value in any of these food areas? Certainly the economics are no longer a preeminent limitation. As a matter of fact, lactose now has a major price advantage over sucrose. Perhaps we haven't asked the right questions, or we haven't understood the answers, or we haven't made the right tests or the right comparisons, or presented the right results in the right way to the right people. Perhaps it's a matter of communication.

It's not that lactose is without a point of difference among nutritive carbohydrates. We know it's different. For example, it is a reducing disaccharide and it contains galactose. It differs from other carbohydrates with respect to osmotic pressure, solubility, physical forms, browning, flavor, sweetness, vapor pressure and crystallization behavior. It promotes absorption of calcium from the digestive tract. No other carbohydrate does this. Might this mean that for reasons of skeletal strength it should be consumed in a wider variety of foods?

Incidentally, what is the U.S. consumption of lactose? How does it compare with the consumption figures for cane, beet and corn sugars? Annual lactose consumption is about 4.5 billion pounds or approximately 21 pounds per capita, broken down as follows:

Milk Products	Million Pounds
Fluid & Frozen	3,200
Dry & Concentrated	1,030
Byproducts	270
ANNUAL CONSUMPTION	4,500

This is more than 4 times the consumption of corn sugar, 1-1/3 times the consumption of corn syrup solids, 70 percent of beet sugar consumption and about 1/3 the consumption of cane sugar on a per-capita basis. Obviously lactose is a major dietary carbohydrate. This may suggest that the question of "tolerance" is without practical significance when lactose is consumed in a normal dietary pattern.

Might hydrolyzed lactose be of value in some product applications? Papers to be given later in this conference will answer this question.

Turning to the literature, we find it sprinkled with suggestions that lactose protects certain food flavors, fragrances, and color. Can these properties be translated into concrete advantages capable of influencing food selections made in a free and competitive marketplace? It is apparent that

much remains to be done before we can fully answer the question--"What does whey have to offer?"

In summary, I think it fair to say that the WPI food standards amendment program provides an exciting marketing thrust and represents a first step toward getting the whey industry "in-step-with-time" as measured by the needs, wants and trends of the marketplace.

To keep the ball rolling and to define clearly what is still to be done and how to accomplish it, I suggest a 4-point action plan:

1) Commit full attention, resources, and effort to the identification and production of products which, through consumer appeal, will earn a fair return in a free market. Recognize that by doing this, the whey industry's contribution to our national goals relating to both the efficient use of food energy and to environmental quality will be maximized--simultaneously and automatically.

2) Carry out an immediate, in-depth analysis of each new market to determine its size, ingredient requirements, competition, and direction.

3) Integrate this new marketing input with technical and production programs so coordinated as to build and deliver products meeting the functional, nutritional, and economic needs of our industrial customers and the consumers they serve.

4) Maintain and promote close cooperation with the user food industries, with their trade associations and their member companies, with those Government agencies having responsibility for and knowledge of our national goals, policies, regulations and technology and, equally important, with those members of the academic community having technical and marketing expertise to offer.

Finally, I want to stress that the success of this or any alternate plan will depend largely on our ability to communicate quickly and effectively both within and between the industrial, academic, and Governmental communities as well as between the many academic disciplines whose contributions will be needed. It will be a demanding job. But the results measured in terms of market penetration and economic performance will be rewarding and exciting.

NEW USES FOR THE HEAT-ACID WHEY FRACTIONATION PRODUCTS

PAVEL JELEN

University of Alberta
Edmonton, Alberta T6G 2E2

The process of heat-acid fractionation of whey into whey protein coagulum and "deproteinated" whey has been known for a long time. The process removes about 50 to 65 percent of the total nitrogenous matter from the whey, hence the quotation marks. In short, the process consists of the following main steps:

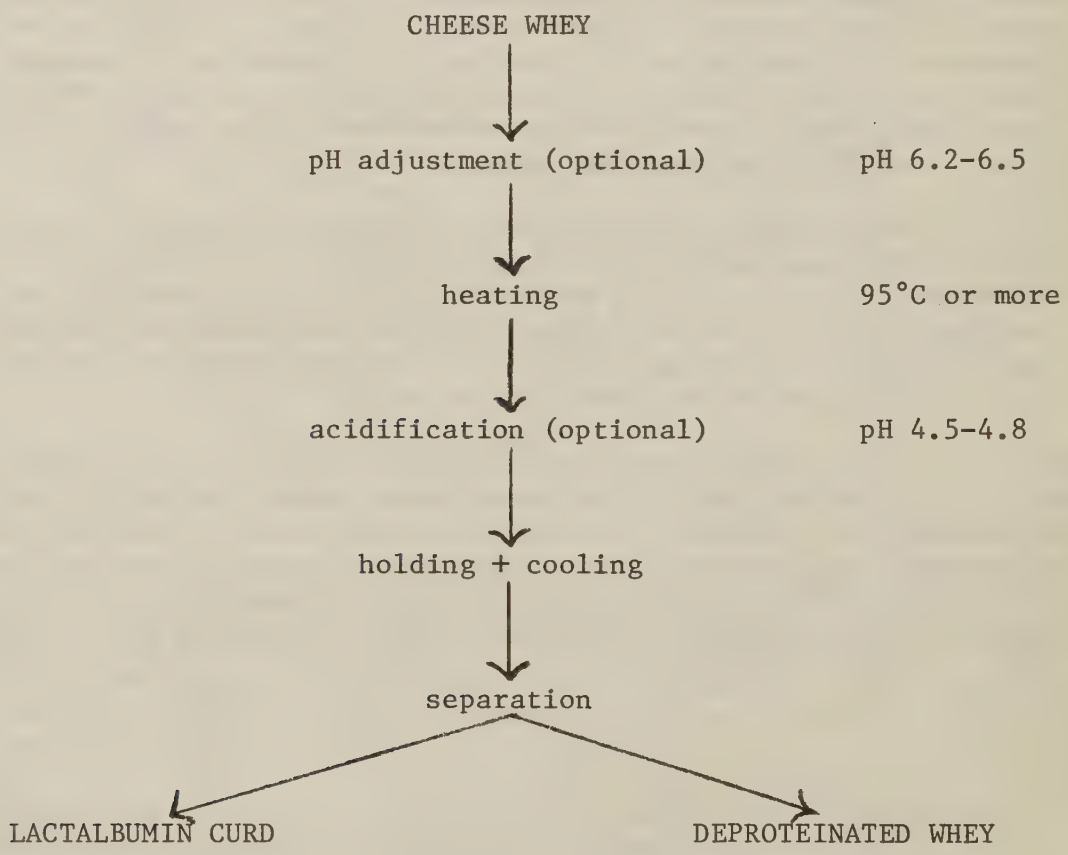


Figure 1.--The heat-acid deproteination process.

1) The sweet or acid whey is heated to 95°C or higher, with or without previous pH adjustment to between 6.2 and 6.5.

2) The hot whey is acidified, if necessary, to obtain a pH of 4.5 to 4.8.

3) The whey is held for 15 to 30 min and/or gradually cooled to the convenient separation temperature.

4) The coagulum is separated by centrifugation, filtration, by decanting the deproteinated whey, or by using draining techniques similar to those in cottage cheese production.

The main product, lactalbumin curd (LC), contains about 80 to 85 percent moisture. Depending on whether sweet or acid whey was used, and whether pH adjustments were made, the curd contains anywhere from 40 to 65 percent protein and from 8 to 35 percent ash on the moisture-free basis (4,5).

Numerous references and patents relating to this process can be found in the literature; references 4, 12, and 13 are just a few examples. Recently, a streamlined, continuous version of the process was reported (11) whereby the heating, acidification, and separation are accomplished by an automatic self-cleaning desludging centrifuge.

Industrial utilization of the heat-acid precipitation does not appear to be widespread at the present time. The main reasons may be:

1) The relatively large volumes of liquid that have to be processed as compared to the yield. Normally about 20 to 25 pounds of whey is needed for every pound of curd.

2) The laborious separation of the coagulum. This requires either intensive labor or specialized equipment--such as a desludging centrifuge, solid-bowl centrifuge, or self-cleaning filter.

3) The alleged low utilization potential of the curd. The curd is insoluble and gritty (14); however, various dairy and nondairy experimental uses for it have been reported (9).

The volume of material that has to be processed can be cut down by evaporating the whey to between 12 and 20 percent total solids (TS) if an evaporator is available. However, reports have appeared relatively recently (2,10) that the resistance of whey proteins to heat denaturation increases as the wheys are concentrated, up to a maximum at 20 percent TS. To find out whether this would have an effect on relative protein yields, we ran some deproteination experiments with fresh cottage cheese whey at 5.8, 11.7 and 16.8 percent TS. The evaporation was done in a laboratory glass rotary evaporator, and the heating was carried out both without previous pH adjustment (that is, at about 4.5) and with samples adjusted to pH 6.5.

The results (Figure 2) show that there is no decrease in protein yield as a result of concentration when measured by Kjeldahl analysis of the supernatants from the centrifuged samples, or as the volume of the centrifuged

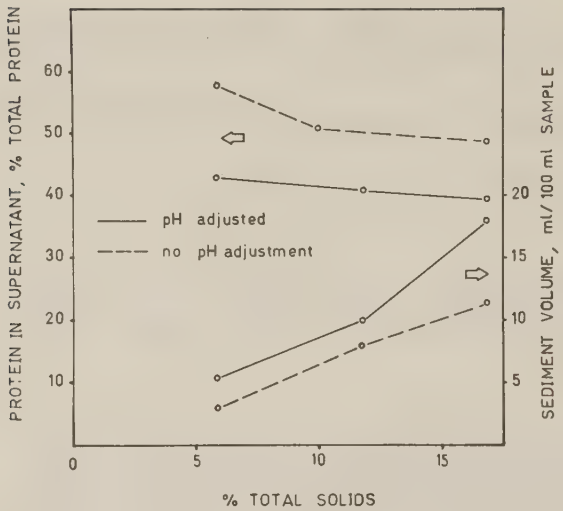


Figure 2.--Effect of concentration on effectiveness of the heat-acid deproteination.

sediment. Adjustment of the pH to 6.5 before heating and readjustment to pH 4.7 after heating increased the protein and sediment yields at all three TS levels. This is in agreement with literature (10). Further experiments with the process are under way; one of the preliminary results worth mentioning is a possible increase in yield by heating the whey at pH 3.5 rather than 6.5, then readjusting the pH to 4.5 to 4.8 by alkali after the heating.

Regardless of the method used, the resulting curd is white or yellowish (depending on whether any color was used in making the cheese), has a bland flavor, and is pasty or crumbly depending on the water content. Use of acetic acid for the acidification is preferable to HCl with respect to taste. The fresh curd can be mixed with cream, flavored with some condiments like chopped onions, red peppers, chive, etc., and consumed as spread or a dip. It can be used as a low-fat alternative for sour cream for potatoes. A sweet, creamy dessert can be prepared by adding vanilla, sugar, chocolate, or fruit syrup to the curd. Results of an organoleptic evaluation of four such products are summarized in Table I. The table is included mainly to demonstrate the potential for developing similar products. The composition of the ingredients is purposely not given because this was not varied to optimize the organoleptic scores.

TABLE I.--Mean[a] taste panel scores[b] of four fresh lactalbumin curd products.

	Product ingredients[c]			
	Ground bacon ends	Chopped radish, red pepper	Green chive	Sugar, chocolate
Appearance	6.4	6.8	6.4	4.9
Flavor	6.5	5.9	5.0	4.3
Texture	5.1	5.0	5.3	4.3
Overall quality	5.9	5.4	5.3	3.9

[a]Eight panelists.

[b]According to 9-point scale (9--like extremely, 5--neither like nor dislike, 1--dislike extremely).

[c]In addition to lactalbumin curd and 10 percent butterfat cream.

The fresh curd also seems to have a potential as a meat extender in certain ground meat products. We experimented with its addition to ground beef meat balls and fresh pork sausage (6). With ground beef meat balls, we found that only about 5 to 10 percent of the meat can be replaced by the curd without adversely affecting the texture and overall quality of the meat balls when deep-fried. Softening of the curd, observed in the Lee-Kramer shear-press texture measurements, increased with increasing levels of added curd. Weight losses upon frying decreased with increasing curd replacement, but so did the moisture content of the fried balls. This suggests higher fat absorption in the fried balls as the liquid fat fills the voids left by the vaporized water.

We had better success with fresh pork sausage. Here 20 percent substitution of the meat by the curd actually slightly improved the taste panel scores (Table II) as compared to the control. Some of the panelists considered the

TABLE II.--Formulation and taste panel scores of boiled fresh sausages, with and without albumin curd.

	Control (without curd)	Experimental (with curd)	F ratio
Formulation			
Fresh pork, g.	1000	800	
Lactalbumin curd, g.	-	200	
Red pepper, g.	1	1	
Black pepper, g.	4	4	
Sage, g.	2	2	
Nutmeg	a few grains	a few grains	
Mean[a] taste panel scores[b]			
Flavor	6.7	7.3	1.02[c]
Texture	5.7	6.2	0.57[c]
Overall quality	6.1	6.8	1.40[c]

[a]Thirteen panelists.

[b]According to 9-point scale: 9--like extremely, 5--neither like nor dislike, 1--dislike extremely.

[c]Not significant.

sausage readily marketable. One problem in the sausage (as well as in the meat balls) was their somewhat greyish appearance after cooking caused by the white curd. A test with 300 p.p.m. $NaNO_2$ added per 100 g. sausage material showed that the curd addition had a negligible effect on the curing reaction in the sausage.

We attempted to determine emulsion capacity of the dried curd in a model system as an indicator of its potential in the fine meat emulsions, e.g., wieners. In the test system of 50 ml. H_2O and 15 ml. corn oil, the finely mortar-ground, freeze-dried curd had a peculiar effect. Immediately after blending in a Sorval omnimixer, visible separation into two phases occurred; the lighter phase, however, was a stable oil-water emulsion, and its volume increased with increasing amounts of the lactalbumin curd powder (Figure 3). Thus we believe that the dried curd would have a positive stabilizing effect in frankfurters similar to the effect of the fish protein concentrate.

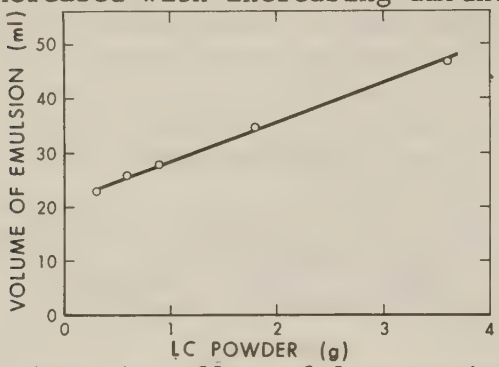


Figure 3.--Effect of freeze-dried powdered lactalbumin curd (LC) on volume of emulsion formed in 50 ml. H_2O and 15 ml. corn oil.

It is claimed that undenatured, water-soluble whey protein concentrate, prepared by methods other than heat precipitation, is desirable for human food applications. However, the processing costs are likely to be higher for the undenatured protein, and the cost/benefit ratio is often important for further use by food manufacturers. It appears that for some meat product applications the water insolubility would not be detrimental. For other food applications, e.g., for spreads, soups, beverages, cake mixes, etc., the insolubility might be a problem.

We have tried to resolubilize the heated precipitate by using various enzymes--with little success so far--or by heating in alkaline conditions. This latter method worked very well, and fully soluble material was obtained by freeze-drying the treated curd. A full report will be published in due course after the nutrition implications and food potential of the product are assessed. As an example of possible use, we prepared a dairy spread by reconstituting the dried solubilized heated lactalbumin with 10 percent butterfat cream; the spread had a very smooth texture and good consistency and spreadability.

These few examples of new potential uses of the heated lactalbumin, in addition to those found in literature, seem to indicate that additional profit can be realized by cheese processors if they would take a little initiative and try to sell the whey protein they are now throwing away.

From the standpoint of total whey utilization, and especially pollution control, the heat-acid precipitation does not solve much unless use is found for its byproduct--the deproteinated whey. This material has some useful properties however:

1) It has higher purity with respect to lactose. In lactose production crystallization should be easier from the concentrated deproteinated whey (3).

2) It has remarkable foaming and whipping properties, which may be an advantage or a processing drawback.

3) It has better browning properties than comparable pure lactose solution, probably due to the presence of free amino acids and protein fragments resulting from the heat-acid treatment.

4) The use of acetic acid for the deproteination gives the liquid by-product, when concentrated to about 15 percent total solids, a sweet-sour taste that is quite pleasing.

In our recent publication (8). we discuss our evaluation of the possibility of using deproteinated whey for color improvement of French fries. The results (Table III) showed that both untreated and deproteinated fresh wheys, after 1:1 dilution, were as suitable as the 1.5 percent glucose solution

TABLE III.--Whey-based dipping solutions: their free amino acid content and their effect in improving the color of water-blanched, French-fried potato strips.

No.	Solution			French fry color score[b]
	Type[a]	% Concentration	Free a.a. content (mg/100 ml)	
1	Cottage cheese whey	100 (v/v) 50 (v/v)	102.7	3.0 2.0
2	Cottage cheese whey, deproteinated	100 (v/v) 50 (v/v)	69.5	3.5 1.5
3	Reconstituted whey powder[c]	6 (w/v) 3 (w/v)	88.0	3.0 2.25
4	Reconstituted deproteinated whey[c]	6 (w/v) 3 (w/v)	58.6	2.5 2.25
5	Reconstituted ultrafiltration permeate	6 (w/v) 3 (w/v)	42.0	3.0 1.75
6	Glucose	1.5 (w/v)	-	2.0

[a]Solutions 1-4 were prepared from the same initial batch of whey.

[b]On the basis of 0-4 point discrete scale (USDA, 1966: Color Standards for Frozen French-Fried Potatoes, 2nd ed.).

[c]Dried from 1 or 2 by freeze-drying combined with fluidized bed atmospheric drying.

used commercially today. Drying had no effect on the browning ability of the reconstituted solutions. Similar tests with permeate from ultrafiltration of whey (dry sample kindly provided by Ms. Holsinger, USDA), showed that this material is almost as suitable, even though the free amino acid content of the permeate was somewhat lower than that of the deproteinated whey. Lactose alone, although a reducing sugar, does not have the ability to impart the brown color in French fries or potato chips when used in similar concentrations as deproteinated whey powder. In combination with certain amino acids, e.g., with glutamic acid, satisfactory browning was achieved at lower concentrations of lactose (8).

Another remarkable property of the heat-acid deproteinated whey is its foaming ability--much higher than that of the untreated whey. It may be bothersome at times from the processing standpoint, but it can be one of the strongest "selling points" of this material. After concentration and removal of some lactose by crystallization, the remaining mother liquor can be whipped into a rather stable foam (7). The overrun and stability are functions of total solids content in the mother liquor (Figure 4), which can be controlled by evaporation or by addition of sucrose, soluble starch or other solutes. The untreated mother liquor foam is not very palatable because of high salt and acid content, but it probably could be developed for use in agriculture or home gardening as a protective foam against night frosts. Unfortunately, for possible use in a garden, the mother liquor cannot be foamed by spraying from a pressurized can using nitrous oxide as the propellant (at least we have not succeeded in our attempts).

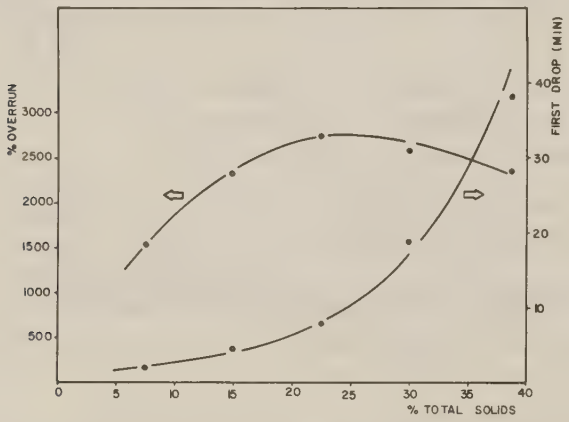


Figure 4.--Effect of total solids concentration on percent overrun and stability of foam from heat-acid deproteinated whey.

For human foods, the salt and acid content of the mother liquor would have to be reduced. We accomplished this in a laboratory by dialyzing against water for 16 to 24 hours. For large-scale manufacture of the whippable isolate, ultrafiltration of the heat-acid deproteinated whey would seem to be the obvious choice, although we had no opportunity to try it ourselves. Condensing and/or freeze-drying of the dialyzed mother liquor did not affect whipping properties of aqueous systems containing these residual whey protein fractions. Solutions with about 2 to 4 percent protein and 50 percent or more sucrose were whipped into quite palatable and stable foams (7), suitable as cake frosting or a dessert whip. Baking experiments with these foams were successful when a simple meringue was desired. However, use of the dried whippable isolate in place of egg white in angel cake formulations resulted in similar disasters as reported by USDA last year (1).

Finally, we attempted to make an Italian-type salad dressing from the acetic acid deproteinated whey condensed to about 15 percent total solids, using roughly 2 to 3 parts whey and 1 part sunflower oil, plus appropriate condiments like oregano, pimento, etc. The oil in the recipe was very useful

for controlling the foaming, which would otherwise create a problem of how to "shake well before using."

In summary,

1) The heat-acid precipitation of lactalbumin is probably the simplest method for realizing additional profit from whey processing, especially for smaller cheesemakers.

2) The experiments with dips, dairy spreads, and meat products suggest new possible outlets for heat-coagulated lactalbumin.

3) Whipping properties and browning ability may be considered the two most useful properties which may help in further utilization of the heat-acid deproteinated whey.

LITERATURE CITED

(1) DeVilbiss, E. D., Holsinger, V. A., Posati, L. P., and Pallansch, M. J.

1974. Properties of whey protein concentrate foams. Food Technol. 28 (3): 40.

(2) Guy, E. J., Vettel, H. E., and Pallansch, M. J.

1967. Denaturation of cottage cheese whey proteins by heat. J. Dairy Sci. 50: 828.

(3) Haken, M., and Hartman, J.

1972. Separation of lactose from concentrated whey. Prum. Potravin 23: 176 (in Czech).

(4) Harwalkar, V. R., and Emmons, D. B.

1969. Low ash lactalbumin as a byproduct of lactose production. Can. Inst. Food Technol. J. 2: 9.

(5) Jelen, P.

1974. Unpublished data.

(6) Jelen, P.

1974. Use of coagulated lactalbumin from cheese whey in ground meat products. Submitted to J. Food Sci.

(7) Jelen, P.

1973. Whipping studies with partially delactosed cheese whey. J. Dairy Sci. 56: 1505.

(8) Jelen, P., and Jadhav, S. J.

1974. Color improvement of French fried potatoes using lactose or cheese whey. J. Food Sci. 39: 1269

(9) Mann, E. J.

1971. Lactalbumin and its uses. Dairy Ind. 36: 538.

(10) Nielsen, M. A., Coulter, S. T., Morr, C. V., and Rosenau, J. R.

1973. Four-factor response surface experimental design for evaluating the role of processing variables upon protein denaturation in heated whey systems. J. Dairy Sci. 56: 76.

(11) Pien, J.

1971. Process for extracting proteins from whey. U.S. Patent 3,583,968.

(12) Schulz, M. E., and Lange, W.

1952. A method for preparation of edible protein from whey. Germ. Patent 817,547 (J. Dairy Sci. Abstr. 14:508).

(13) Scott, E. G., and McDonald, G. W.

1952. Manufacture of lactalbumin. U.S. Patent 2,497,420.

(14) Wingerd, W. H.

1971. Lactalbumin as a food ingredient. J. Dairy Sci. 54: 1234.

SOLID ANIMAL FEEDS

FROM WHEY AND WHEY PRODUCTS

R. E. HARGROVE AND G. P. LYNCH

Dairy Food and Nutrition Laboratory, ARS, USDA
Beltsville, MD 20705

Since Congress initiated antipollution legislation under the Clean Water Restoration Act of 1966, no commodity within the dairy industry has received as much time, attention, and money as has cheese whey. One of the results of this increased attention has been the development of ultrafiltration (UF) equipment for whey processing which provides the dairy industry with a useful tool for the fractionation and removal of undenatured proteins from whey. (1,4)

We can visualize many food uses for the whey protein; however, recovering the protein from whey by UF creates a new waste product in the form of permeate or deproteinized whey. Before the UF process can be fully utilized by industry, some provision must be made for the disposal of the tremendous quantities of permeate that will be available. The permeate fraction represents 90 percent of the original volume, still contains most of the whey solids, and has a BOD only slightly lower than the starting whey. Developing uses for this deproteinized whey, particularly the acid permeate from cottage cheese whey, has been the objective of one of our recent studies.

Although we have considered several potential uses for the permeate, animal feeding seems to provide one of the greatest outlets. (2) We have shown that the permeate may be easily spray dried, regardless of acidity, but the costs for drying are just as great as for drying the whole whey. (3) We are proposing a method for the preparation of solid feed blocks to avoid this costly drying operation. In my allotted time, I'd like to describe the process we have developed for converting the whey permeate to solid animal feed, to indicate some of the parameters in formulating a solid animal feed, and to give some of the results of preliminary feeding trials with young calves and steers.

The general procedure used for making the feed blocks is as follows: acid cheese whey was obtained from a local cottage cheese producer and usually processed immediately. An Abcor ultrafiltration unit equipped with HFA 180 modules was used for fractionation. Operating temperature was 120°F. with an operating pressure of 45 p.s.i. Ninety-five to 98 percent of the protein was removed as a concentrate and the permeate or deproteinized whey passed to a holding tank. The permeate was then forewarmed to 150°F. through a Mallory

heater and passed to the evaporator. In this case, we used a Wiegand falling-film evaporator where it was condensed in 2 to 3 passes. After the first pass or on reaching a total solids content of about 30 percent, the permeate was neutralized in the range of pH 6.2 to 6.4 with anhydrous ammonia. Rather than metering in anhydrous ammonia, we could have used concentrated NH_4OH.

When a total solids (TS) level of 65 to 70 percent was reached (this was indicated, at a concentrate temperature between 105 and 110°F., by a hydrometer reading of 40 to 41° Baume) the concentrate was pumped directly into forms. Forty-pound Wilson-type cheese hoops with paper liners served as excellent forms. Sturdy cardboard cartons have been used with equal success. The solidification process began almost immediately and blocks were firm after a few hours. Forms were usually removed after 12 to 15 hours, and the blocks were air dried for 1 to 2 days. They were then ready for feeding as "lick blocks." The process is that simple. A 45-to-50-pound block made in this manner is hard, but still contains from 25 to 30 percent moisture. Each block represents about 90 gallons of the liquid permeate. A 200-to-300-pound steer may consume one of these blocks in a week or less.

Now let's take a look at some of the factors affecting solidification of the concentrate. The key factor is degree of concentration. This is illustrated in Figure 1. Beginning at the bottom left, we can see that solidification began almost immediately when concentrated to 69.5 percent TS. By the time we were able to get a reading on the penetrometer, (5 min.) the concentrate was setting up rapidly. In ten minutes the block had formed. Slight decreases in solids level are significant as the slide shows. The batch concentrated to 59.5 percent solids required 90 min. before a penetrometer reading could be obtained, and it remained soft and mushy for several days.

To explain the solidification process, we looked at the lactose content and the rate of lactose crystallization. Figure 2 shows the rate of lactose crystallization in three concentrates of different solids. Concentrates were held at a constant temperature and samples removed periodically and measured for crystallization with a polarimeter. Most of the crystallization occurs in the first hour regardless of total solids. The greater the solids, the greater the percent of crystallization. One can almost predict the extent of crystallization from the total solids content.

The significance of lactose content to solidification was further emphasized by the fact that even partially fermented permeates could not be formed into blocks. Although the permeate served as an excellent growth medium for lactose-fermenting yeast and bacteria, and protein yields were significant, the fermented permeates could not be solidified. A reduction of 20 percent or more of the lactose prevented solidification.

Other factors which were important in block formation were: concentrate holding temperature, pH, and agitation. The type and degree of concentrate stirring proved to be more significant than the product holding temperature. The rate of solidification was essentially the same from 80 to 130°F. Very low temperatures of 35 and 40°F. did increase hardening.

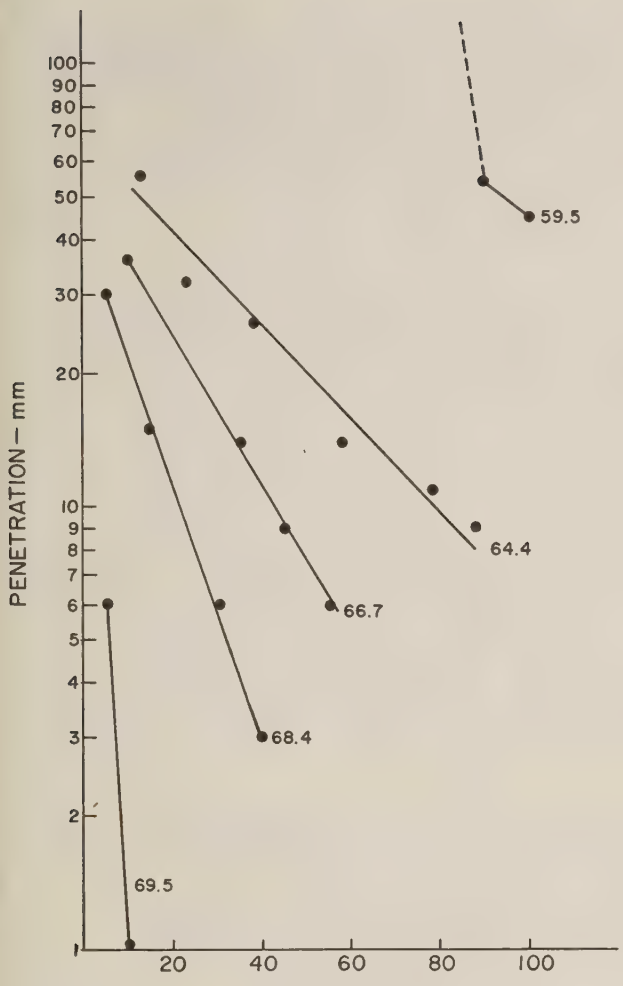


Figure 1.--Effect of solids content of concentrated deproteinized whey on solidification rate.

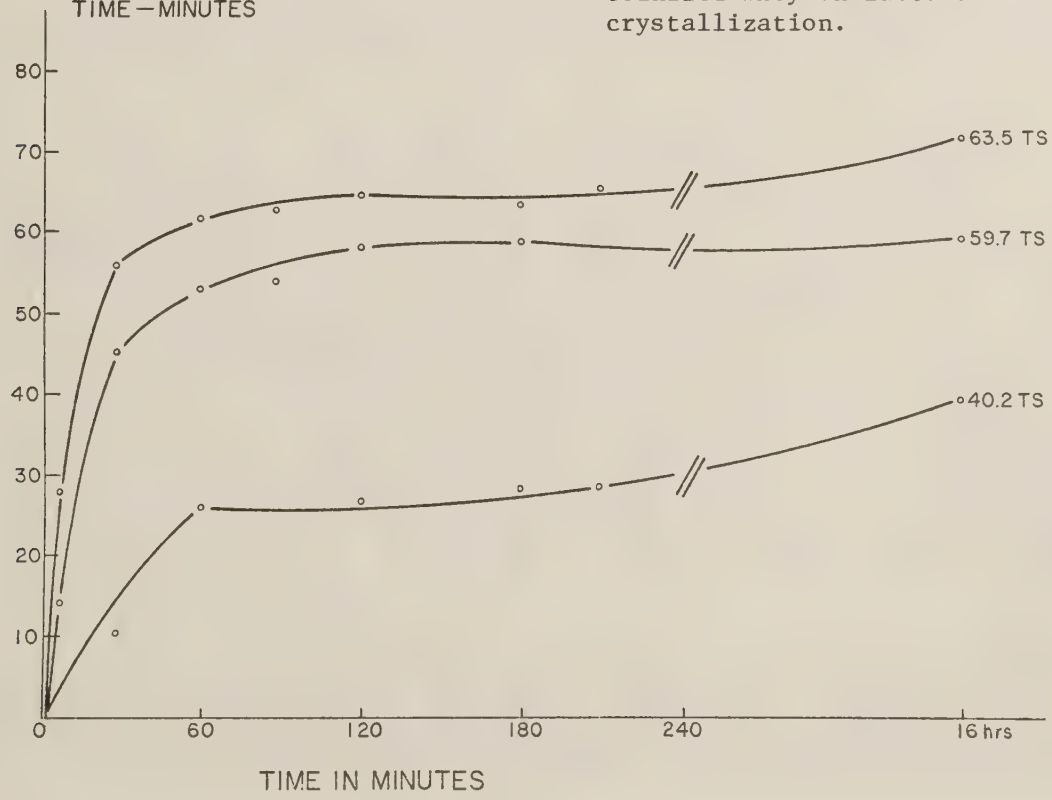


Figure 2.--Effect of solids content of concentrated deproteinized whey on lactose crystallization.

Agitation is important as a means of slowing solidification. Many additives would be added to the concentrate just prior to the final pass through the evaporator. Others, such as dry soybean meal would be added after concentration. If addition of ingredients must be delayed, vigorous agitation with a swept surface type of mixer will prevent solidification from starting for at least 2 hours. Rotating blade type mixers are not adequate; they tend to cavitate and solidification of the edges will proceed.

Although not critical, pH is important. After sufficient concentration, both whey and permeate will solidify, regardless of pH. However, the body and characteristics of the blocks are different when made from acid and sweet whey or permeate. Blocks with an acid pH are darker, and they become very rough and crinkled after one or two months of storage. In contrast, blocks from sweet permeate are whiter, they have a smooth texture, and they remain smooth even after several months of storage. It is extremely important to neutralize at the right time. If the raw product is neutralized with ammonia prior to processing, much of the ammonia is lost during condensing and the pH will shift downward. If the pH is adjusted after final concentration, just prior to going into the forms, the viscosity will increase tremendously and pumping will be difficult, if not impossible. Therefore, adjustment should be made after the first pass through the condenser, or at 30 to 35 percent solids. At this point viscosity is not affected significantly and very little change in pH will occur during the final pass.

As already indicated, the liquid permeate contains all the ingredients originally found in the whey except the protein and small amount of fat. This includes lactose, lactic acid, free amino acids, minerals and nonprotein nitrogen (NPN) compounds. In addition to the whey nutrients, the permeate serves as an excellent binder for many additives to the feed blocks.

Table I illustrates some of the changes that can be brought about by additives. The control is a typical block made from acid cottage cheese whey

TABLE I.--Typical analyses of experimental feed blocks.

	Control	NH_3	Urea	50% Whey	100% Whey
	Percent				
Moisture	30.4	29.6	26.9	30.4	24.1
Lactose	50.2	52.0	52.4	47.6	48.9
Protein	0.8	0.8	0.8	4.2	7.8
Protein equivalent	2.9	6.7	12.4	9.2	13.6
Ash	8.5	8.2	9.0	8.1	8.7
pH	4.4	6.2	6.1	5.9	6.2

permeate with a pH of 4.4. The block designated NH_3 is from the same permeate but has been neutralized to pH 6.2 by addition of NH_4OH. Since ruminants are able to obtain up to 30 percent of their nitrogen needs fron NPN, neutralization with ammonia and the formation of ammonium lactate is very beneficial. The added nitrogen boosted the protein equivalent from 2.9 to 6.7 percent. In addition, the neutralized blocks were consumed more readily and in greater quantities in calf-feeding studies. Reducing the extreme acidity of the cottage-cheese whey permeate improved the palatability of the blocks. Urea increased the protein equivalent to 12.4 percent. True protein can be increased by fortification with a variety of materials. A blend of 50 percent whey with the permeate increased protein from 0.8 to 4.2 percent. A block from 100 percent whey, i.e., whey which has not gone through the UF procedure, would contain close to 8 percent true protein with an equivalent of 13.6 percent when NPN is considered.

Other materials used for fortification included potato solubles, brewery wastes, alfalfa meal, soybean meal, and molasses. Molasses, of course, was added only to increase palatability. All additives could be incorporated into the concentrate without difficulty. There were some limitations, however, which should be mentioned. Neither free ammonia nor urea were popular with the calves when used in excess. Therefore, neutralizing with ammonia should be limited to pH 6.0-6.5 and urea fortification should be limited to 0.1 to 0.15 percent in liquid permeate. A maximum of 10 percent soybean meal or similar dry material could be added to the final concentrate. It is clear that, with certain limitations on quantity, fortification presents no problem.

Many have asked if whole whey, rather than deproteinized whey, can be processed into solid blocks. Since analytical data on whey blocks have already been shown, one would guess that the answer is yes. With whole whey, however, the solids level is even more critical; it must exceed 70 percent rather than 65 percent to solidify.

Other nutrients in the whey blocks, as shown in Table II, provide a good source of essential salts, trace minerals, and vitamins. In the ultrafiltration of whey, low-molecular-weight compounds are known to pass through the modules into the permeate. This is also indicated here by the comparison of two blocks made from neutralized cottage cheese whey, one made entirely from the permeate and the other from a 50/50 blend of the permeate and the whole whey. Very little difference is found in the mineral content. Iron seems to be an exception, but we are convinced that this is caused by contamination of our water. Slight iron deposits in our equipment subsequently find their way into the permeate. The 7 vitamins normally found in whey were also found in these two representative blocks. Except for some differences in choline and folic acid, the block made from 100 percent whey permeate had essentially the same vitamin content as the one made with 50 percent whole whey. In general, the values for the vitamins in the blocks are in agreement with those listed in the literature for dried whey. (5)

Feed blocks are being evaluated in controlled feeding studies with young calves and steers at our Ruminant Nutrition Laboratory. Feeding trials with blocks of varying composition and additives are still in progress; however, the results of initial feeding tests are complete and will be reported here.

TABLE II.--Minerals and vitamins in feed blocks.

	Blocks made from neutralized cottage cheese whey	
	100 percent UF permeate	50/50 blend permeate/whole whey
Minerals	Percent	
Calcium	1.2	1.2
Magnesium	0.1	0.1
Phosphorus	0.6	0.7
Potassium	2.3	2.1
Sodium	0.8	0.8
	Parts per million	
Copper	1.1	1.2
Iron	5.5	2.5
Zinc	26.6	30.0
Aluminum	19.1	19.5
Boron	2.7	2.7
Barium	0.6	0.6
Manganese	0.6	0.7
Chromium	2.0	2.2
Strontium	4.0	4.1
Vitamins	mg. per kg.	
Riboflavin	13.7	14.3
Pantothenic acid	46.0	46.4
Niacin	6.2	5.9
Thiamine	4.1	4.1
Choline	2550	3180
B_{12}	.02	.03
Folic acid	.13	.21

Our first feeding study was made with young calves to obtain information on feed intakes, body weight gains, and the effect of supplementing the blocks with ammonia and urea.

Sixteen Holstein steer calves averaging 90 kg. body weight were assigned to four treatments. One group without blocks served as a control, one group received an acid block, one received ammonia-neutralized blocks and the fourth group received urea-supplemented blocks. All calves received a 9 percent protein pelleted ration of alfalfa meal and corn ad lib. Blocks were available in feed troughs ad lib. Initial and final weights were taken. Individual intakes of both the pelleted feed and blocks were recorded daily for 60 days. Venous blood samples were taken at the beginning and end of experiment to determine free plasma amino acids.

Results of this feeding trial are shown in Table III. Initially the calves showed some reluctance to consume the blocks. However, after a week,

TABLE III.--Results of feeding permeate blocks to calves.

	Control (feed only)	Type block		
		Acid	NH_3	Urea
	Kilograms			
Average daily weight gain	1.2	0.9	1.2	1.0
Average daily intake (dry matter)				
Feed	5.0	4.8	3.6	3.8
Block	-	0.8	1.1	1.0
Total	5.0	5.6	4.7	4.8
Ratio of dry-matter intake to weight gain for 60-day test	4.0	6.0	4.0	4.9

all blocks had lick marks and some blocks were extremely chewed. Statistically, no significant difference was shown in final body weights or daily gain due to permeate block feeding. Feeding of the blocks did not improve animal performance over the pelleted ration. However, the animals given the ammonium and urea blocks took markedly less of the pelleted ration. On a dry-matter basis, the calves' daily intake from the blocks ranged from 0.8 kg. for the acid blocks to 1.1 kg. for the ammonium blocks.

These data are summarized in Table IV. Calves on the blocks were able to consume from 15 to 24 percent of their total dry matter from the blocks with no reduction in body weight. The percentages of pelleted ration replaced is

even more significant with the neutralized and urea blocks. These data indicate a potential for considerable saving in feed costs by the use of the permeate block.

TABLE IV.--Effect of permeate block on calf feed intake.

Block consumption	Type block		
	Acid	NH_3	Urea
Percent of total dry matter	14.9	24.4	20.4
Percent of feed replaced	3.6	29.0	25.4
Block-to-feed ratio	1:5.7	1:3.2	1:3.6

In order to get a more accurate nutritional evaluation of the blocks, free plasma amino acids were determined. Results of these data are summarized in Table V. Blood amino acids were essentially the same in the control animals

TABLE V.--Free plasma amino acids of calves fed permeate blocks.

	Control (feed only)	Type block		
		Acid	NH_3	Urea
Ratio essential to nonessential amino acids	0.46	0.36	0.37	0.47
Essential amino acids (μM./100 ml.)	77.2	54.2	44.7	75.1
Urea (μM./100ml.)	67.0	44.9	35.8	90.0
NH_3 (μM./100 ml.)	25.3	31.8	44.6	28.0

as in those on the blocks. Ratios of essential to nonessential amino acids were unchanged. Neither were the urea or ammonia plasma levels elevated significantly by supplementation. We did find that the ammonia group had lower essential amino acid levels ($P < .05$) than the controls or urea treatments. This suggests that more attention needs to be paid to the amino acid or protein intakes of calves receiving permeate blocks in spite of the fact that growth rates were not different among treatments.

In conclusion, I might add that data from more recent feeding trials with equal mixtures of whey and permeate and other supplements show even more promise. Eventually, we hope to test the whey blocks with lactating animals. It is hoped that the process outlined here for making whey blocks will provide cheese processors with a practical alternative for treating whey for disposal. In addition, we believe that considerable saving in feed costs can be obtained if whey blocks are incorporated in the diet of animals.

LITERATURE CITED

(1) Fenton-May, R. I., Hill, C. G., Jr., and Amundson, C. H.

1971. Use of ultrafiltration/reverse osmosis systems for the concentration and fractionation of whey. J. Food Sci. 36: 14.

(2) Hargrove, R. E., McDonough, F. E., and Alford, J. A.

1974. Whey fraction converted into animal feed - without drying. Food Eng. 46: 77.

(3) Hargrove, R. E., McDonough, F. E., and Alford, J. A.

1973. Production and properties of deproteinized whey powder. J. Dairy Sci. 56: 63.

(4) McDonough, F. E., Mattingly, W. A., and Vestal, J. H.

1971. Protein concentrate from cheese whey by ultrafiltration. J. Dairy Sci. 54: 1406.

(5) Webb, B. H., Johnson, A. H., and Alford, J. A.

1974. Fundamentals of Dairy Chemistry. 2nd edition. The Avi Publishing Company, Inc., Westport, Conn.

PROGRESS IN DEVELOPMENT OF WHEY-SOY DRINK

M. J. PALLANSCH

Agricultural Research Service, USDA
Washington, DC 20250

For many years, nonfat dry milk has been purchased by the U.S. Department of Agriculture for distribution to needy people abroad by the U.S. Agency for International Development (AID). About 18 months ago, however, USDA's Credit Commodity Corporation did not have any nonfat dry milk available that was not already committed elsewhere; in fact, we were importing dry milk from abroad. Consequently, in April 1973, AID officials contacted the Department, asking for assistance in finding a substitute for nonfat dry milk for use in the U.S. Food-for-Peace programs.

A joint USDA-AID effort was immediately begun to develop a nutritious beverage powder mix specifically formulated for preschool children receiving inadequate protein. It was not intended to serve as the sole source of food, but to be a dietary supplement. The first and most important decision to be made was that as much whey as possible should be used in the product. Additional protein was to be supplied by soy. Another important decision, in my opinion, was to work with the Whey Products Institute in order to gain the cooperation of the dairy industry in an effort to develop the product, if possible, within one year.

When the first ad hoc committees began to meet, the following time schedule for production of the substitute powder was set:

	Step	Date
1.	Initial contact with ARS by AID	4/8/73
2.	Produce test quantities	8/15/73
3.	Test acceptability in six countries	11/30/73
4.	Obtain approval from Processed Foods Committee and CCC Board	12/14/73

5. Issue first written invitation to bid 3/1/74

6. First production sample delivered 4/17/74

After much eye-rolling and gnashing of teeth about the brevity of the schedule, the first test quantities of whey-soy drink powder were produced about four months after the initial contact. Final specifications were approved by the Processed Foods Committee and the CCC Board and the first invitation to bid was issued on March 1, 1974. Exactly one year from the initial contact, the first production samples were delivered by the industry and are now being consumed in South America.

First of all, pilot plant runs were made by the ARS Dairy Products Laboratory in order to gain information about how the product should be formulated with whey in order to meet the nutritional requirements for preschool children. Whey contains levels of sodium and potassium considered to be too great for ingestion by very young children. Because of the high salt concentration of the whey, a high-molecular-weight material was used as a diluent to reduce the osmotic activity of the water in the reconstituted beverage. The product was also to be a significant source of calories.

On the basis of the ideas developed and prototypes produced, nutritionists decided that the final formulation of the powder should be as follows:

Ingredient	Percent
Sweet whey solids	41.7
Full fat soy flour	36.9
Soybean oil	12.3
Corn syrup solids	9.1

We met our prime objective in that the product contains 41.7 percent sweet whey solids. Most of the protein is contributed by the soy flour; soybean oil was added to increase the caloric density. Corn syrup solids of high molecular weight were added to reduce the osmolality of the mixture to the point where it could be consumed by children of relatively early age.

A 10,000-pound lot was produced by the industry and shipped overseas for acceptability studies in six developing countries.

This product can be manufactured by using conventional dairy plant equipment. A schematic diagram of the production sequence is Shown in Figure 1. Full-fat soy flour, corn syrup solids and soybean oil were wet blended with fluid sweet whey, heated to 38-43^{o}C., homogenized in two stages using pressures of 175.8 and 38.7 kg./cm.^{2}, pasteurized by a high temperature-short time

procedure at 77°C. for 15 sec., vacuum evaporated to 47 percent total solids, and spray dried. In order to increase the nutritional value further, a vitamin-mineral premix was dry blended into the powder before packaging for shipment.

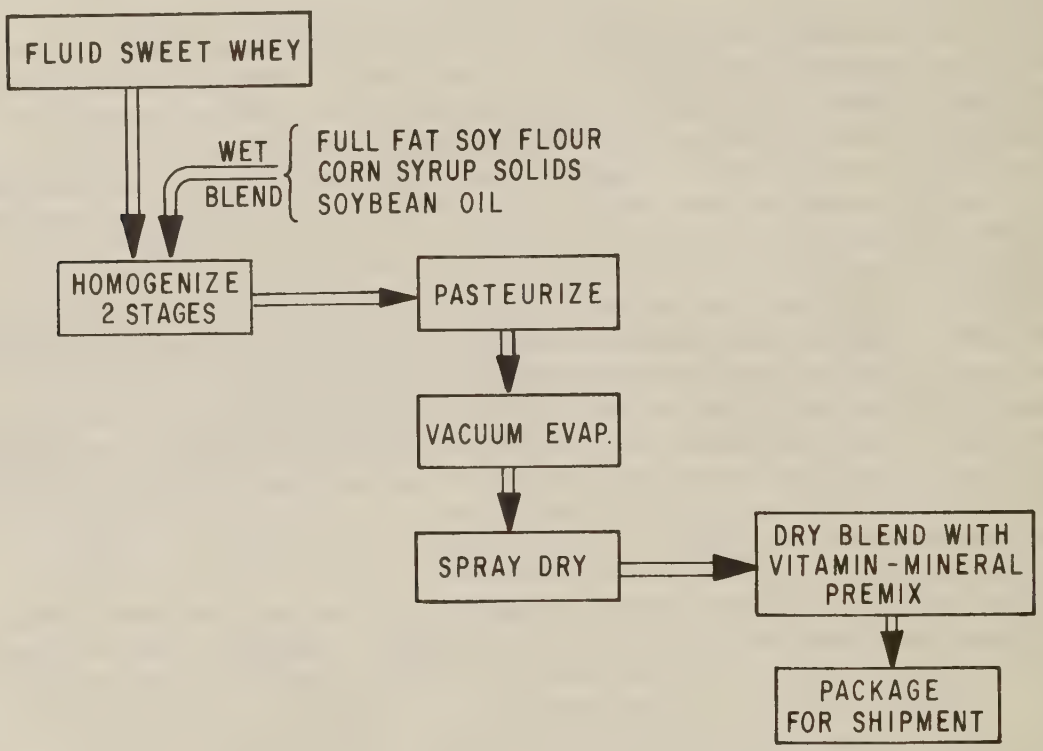


Figure 1.--Production of whey-soy beverage powder.

Overall, the procedure works very well and basically good products have been made. However, there are things which can be simplified or changed and we are always willing to modify when necessary or where good reason can be found to do so.

The product made by this procedure contains exactly what the nutritionists specified. As can be seen from the following proximate composition, the powder is a high-protein, high-fat, high-calorie product (its 47 percent carbohydrate is drawn primarily from the whey) which simulates milk in many respects:

Component	Percent
Protein (Total N x 6.25)	21.2
Moisture	3.9
Ash	5.1
Fat	21.4

Fiber	0.8
Carbohydrate	47.6
Calories/100 g. dry powder	468

The new beverage powder was required to have a protein efficiency ratio based on animal feeding studies of not less than 1.8 and preferably higher. Feeding studies have shown the product to have a PER of 2.1 compared to casein at 2.5. The net protein utilization proved to be 75, compared to 84 for casein.

The product also had to reconstitute easily with water. The physical properties of the whey-soy beverage powder, both unfortified and fortified with vitamins and minerals, are shown in Table I. The physical properties of

TABLE I.--Physical properties of whey-soy beverage powder

Property	Unfortified	Fortified
Solubility index, ml.	4.0	4.3
Dispersibility, percent	89.3	81.7
Sinkability, percent	69.7	81.8
Bulk density, g./cc.		
Untapped	0.48	0.45
Tapped	0.61	0.67

both products resemble those of spray-dried nonfat milk in all respects except that the solubility index is quite high. This indicates that the product has a tendency to settle in water. Under the conditions of use overseas this has not been a problem, however.

Acceptability studies were carried out in six developing countries representing a variety of cultures (3). The results are shown in Table II. Approximately 5,000 children participated in these feeding tests. Their mothers were also given the whey-soy drink and asked for their opinion of this product as food for their children. In only one country, Sierra Leone, was the product found to be unacceptable according to the criteria for acceptability established by Rodier et al. (3). This might be ascribed to the fact that the people there had some previous experience with nonfat dry milk.

In addition to its nutritional quality, the whey-soy drink was also required to have good storage stability. Due to the urgency of the situation,

TABLE II.--Acceptability of whey-soy beverage powder in 6-to-9-day feeding trials in 6 countries.

	Chile	Vietnam	India	Pakistan	Sierra Leone	Dominican Republic
Percentage of children consuming at least 227 ml.	89	70	60	63	49	32
Percentage of mothers liking product	58	42	50	76	70	92

we used accelerated storage studies to determine stability. Taste panel scores on a nine-point hedonic scale (2) for samples stored at -18°C. and 43°C. are shown in Table III. A score of 9 indicates extreme liking for the sample,

TABLE III.--Variation of average flavor scores of whey-soy drink with time of storage.

Sample	Storage temp. (°C.)	Flavor scores				
		Initially	Stored 1 month	Stored 2 months	Stored 4.5 months	Stored 6 months
Fortified	-18	4.5	3.8	3.3	5.3	4.8
	43	-	3.3	3.0	3.1*	2.4*
Unfortified	-18	5.0	4.7	5.0	5.7	6.0
	43	-	4.0	3.5*	3.7*	2.0*

*Significantly different at 1 percent level.

and 5 indicates neither a liking nor a disliking for it. A score of 4 indicates a slight disliking for the sample. American consumers do not like the soy flavor of the product as indicated by the initial scores, but it was well-liked overseas.

It can be seen from the table that at 43°C. the flavor tended to deteriorate after 2 months of storage. However, this temperature represents a radical increase over normal storage conditions. It is thought that for every 10-degree rise in temperature there is a fourfold increase in speed of the chemical reactions that decrease product quality (1). Therefore, we thought

that if the product would store well at 43°C. for 2 or 3 months, it should retain its quality for at least a year under normal storage conditions. On the basis of the data shown here, it was decided that the product would store for one year under moderate conditions. The year has now elapsed and we have confirmed that the product retains its taste quality for this time.

Off-flavors that developed came from the deterioration of the fat present. As would be expected, there is an increase in peroxide value of the fat as storage time proceeds, especially at elevated temperatures. The peroxide values are shown in Table IV for samples of whey-soy drink stored at -18°C.

TABLE IV.--Variation of peroxide values of whey-soy drink with time.

Sample	Storage temp. (°C.)	Peroxide values (meq./oxygen/kg. fat)				
		Initially	Stored 1 month	Stored 2 months	Stored 4.5 months	Stored 6 months
Fortified	-18	7.7	5.5	10.9	1.4	4.8
	43	-	9.9	9.6	59.5	86.0
Unfortified	-18	10.3	15.2	14.9	18.1	15.1
	43	-	18.5	17.2	87.0	163.0

and 43°C. for various times up to 6 months. Contrary to expectation, fortified samples developed less peroxides than the unfortified samples, probably due to the antioxidant effect of some of the constituents of the vitamin-mineral premix used. Elevated peroxide levels were associated with oxidative deterioration of all the samples, however.

The development of oxidized flavor in the samples stored at -18°C. and 43°C. is shown in Table V. The scoring system used ranged from 0 to 4, with

TABLE V.--Variation in intensity of oxidized flavor in whey-soy drink stored for various times.

Sample	Storage temp. (°C.)	Intensity of oxidized flavor (scale 0 to 4)				
		Initially	Stored 1 month	Stored 2 months	Stored 4.5 months	Stored 6 months
Fortified	-18	1.0	0.83	1.3	0.14	0.50
	43	-	0.67	1.0	1.57	3.0
Unfortified	-18	0	0	0	0	0
	43	-	0.33	0.83	0.57	2.67

a score of 4 reflecting extremely oxidized flavor. From our accelerated storage tests, the samples maintain low levels of oxidized flavor until after about 2 to 3 months of storage. This would be equivalent to about one year of storage at 25°C.

Although the product meets the requirements that have been established for storage stability, there are still some unsolved problems. Caking under high moisture conditions is one of these problems and another is solubility of the added iron. If it were not for the presence of iron, wet blending could probably be permitted in the mixing and the dry blending step of the process could be avoided.

Caking was not as serious as had been anticipated. The specifications for the beverage powder were overwritten as far as moisture content was concerned. If the moisture level is held down to about 3 percent in the finished product, there seems to be no particular problem with caking. Tests are currently underway to verify this in our laboratories; we have the cooperation of industry in some of the experiments we are carrying out.

The following changes in the original specifications have been made or are under consideration in response to industry input and experimental results.

1. We now permit the use of defatted soy flour along with additional soybean oil to produce a product similar in composition to the original.

2. We have reduced the moisture content permitted.

3. We now permit alternative processing methods. There have been claims that the evaporation process is too complicated a method to use to reduce soy flavor. Tests have shown that vacuum type deodorizer equipment brings about the same result.

4. Tests are still underway to determine the effect of wet blending the vitamin-mineral premix into the whey mixture prior to condensing and drying. If results of the storage tests prove no marked destruction of vitamin content or deterioration in flavor quality, the specifications will be modified to permit this procedure also.

The Department has purchased over four million pounds of this whey-soy beverage powder in the last few months, less than half of what we would like to have. Now the government has begun to buy nonfat dry milk again. There are presently 100 million pounds of uncommitted nonfat dry milk in CCC stocks and, of course, there is a serious attempt to check inflation by the reduction of Government spending. I do not know what this means. Perhaps from the World Food Congress to be held in Rome in November will come some indication as to the policies the United States Government will follow in maintaining aid programs overseas. In the meantime, our own bill has been vetoed as far as appropriations are concerned, so we cannot tell precisely what the future will hold. We have developed an excellent product. It is a highly desirable dietary supplement for any type of feeding program and will be competitive in the true sense of the word.

I wish to acknowledge the contributions of Eugene Guy, Virginia Holsinger and Nicholas Aceto of ARS, the work of our compatriots in ERS, the Agriculture Marketing Service, and the Agriculture Commodity Stabilization Board and, of course, most of all, the Whey Products Institute and especially the help given us by Jack Walsh and his committees.

LITERATURE CITED

(1) Görnhardt, L.

1955. The nonenzymatic browning of foods. Fette, Seifen, Anstrichm. 57: 270.

(2) Peryam, D. R. and Pilgrim, F. J.

1957. Hedonic scale method of measuring food preferences. In 1. The Methodology of Sensory Testing, p. 9, (Insert, Food Technology 11, No. 9.)

(3) Rodier, W. I., III, Wetsel, W. C., Jacobs, H. L., Graeber, R. C., Moskowitz, H. R., Reed, T. J. E. and Waterman, D.

1973. The acceptability of whey-soy mix as a supplementary food for pre-school children in developing countries. Technical Report 74-20-PR. U.S. Army Natick Laboratories, Natick, Mass.

WHEY PROCESSING CHALLENGES

D. R. BRAATZ

Consolidated Badger Corp.
Shawano, WI 54166

The whey industry as we know it today is a young industry. There was no satisfactory method for drying whey until 1937 when D. D. Peebles was issued a patent for the hydrate dryer. This was the first dryer capable of producing a stable, nonhygroscopic, noncaking dry whey. It was only about 20 years ago that the first standards for edible whey were promulgated by USDA in 1955. And less than four years ago, in June 1971, the Whey Products Institute was formed to enable whey processors to work together as an industry entity.

The age of the industry might explain why it finds itself in a unique position in today's world. In a world of shortages, the whey industry is faced with a burdensome surplus of unprocessed whey solids. Of the approximate 1.5 billion pounds of sweet whey solids available for processing, only 55 percent, or 800 million pounds, are being converted to a marketable product. The remaining 700 million pounds of solids--including about 500 million pounds of carbohydrates, 85 million pounds of protein, and 55 million pounds of minerals, all of which are in demand on today's market--are being disposed of in a variety of ways.

One reason for the large amount of unprocessed whey solids is the unfavorable economics involved in assembling and processing whey from the smaller cheese factories. This unprocessed surplus will diminish as the number of cheese plants decreases and their size increases.

We have seen this trend in Wisconsin, and it appears that it will continue there as well as in the other major cheese-producing areas. In 1958, there were 1,057 cheese factories in Wisconsin. Less than 25 percent of the total available fluid whey from these plants was condensed or dried. During the next 13 years the number of factories declined from 1,057 to 458, and the total available whey processed increased from less than 25 percent to over 75 percent. This does not include cottage cheese whey.

The trend toward greater concentration of whey in fewer plants will require existing whey processors or new processors to make considerable investments in buildings and equipment. They will have to double their condensing and drying capacity to handle these additional volumes. They will also be pressed to find new markets for the additional solids at margins that justify the investment in processing equipment.

These additional volumes of whey available for processing will further compound a problem that already plagues the industry. This is the seasonal variation in the amount of whey solids available for processing. It is estimated that in most areas there is about 160 percent more whey available to process in June than there is in November. Whey processing plants already are filled to capacity during peak periods of cheese production. One of the reasons for lack of production capacity is the economic disadvantage of operating processing equipment at 60 percent capacity for six months out of the year.

The industry is presently faced with an "up and down" market because of seasonal variation in production. If additional volumes of whey are processed, the seasonal variance will be increased. This in turn will create chaos in the market unless the industry can develop and maintain an orderly marketing program.

We might have to take a look at other industries to see how production and marketing handle this seasonal variation in availability of raw material. Many segments of the canning industry, for example, process most of their pack during a two- to three-month period. Then, by necessity, they inventory the finished product and provide a fairly uniform supply for a twelve-month period.

The whey industry is in another unique position in that it processes the byproduct from another industry. With few exceptions, the processor of a basic raw material becomes the processor of any resultant byproducts, especially if disposal is a problem. By and large, the cheese industry has not become the prime processor of whey because of the circumstances under which the whey industry had its origin. Herein lies another challenge. The whey industry must communicate effectively with the cheese industry on both the adverse and beneficial effects of cheesemaking processes and whey-handling techniques on processing and marketing of whey.

There are several areas that require close cooperation between the two industries if we are to meet the challenge of processing and marketing the total amount of whey solids available.

Some supplies of whey still contain traces of annatto, the dye used to provide desirable color in many finished cheeses. Under certain conditions, the use of whey solids containing annatto can cause "pinking" or red discoloration in ice cream and certain types of cheese food.

The use of microbial milk-clotting enzymes in cheesemaking has created problems in that any residual enzyme in the whey may make it unsuitable for certain food applications. Fortunately, it appears that this problem can be corrected by specific heat treatments prior to processing the whey. As new types of milk-clotting enzymes are developed, both the cheese industry and the whey industry must be aware of their possible adverse effect on usage of the processed whey.

The widespread use of phosphated starter media in the cheese industry has not created any problems in regard to whey utilization, to the best of my knowledge. However, as new uses and processing techniques for whey are developed,

we may learn that the phosphate media do indeed present a problem. They certainly are a factor in processing demineralized whey.

We also have the mutual problem of quality control. Quality has been referred to as the biggest asset of the dairy industry. There is no doubt that quality has played an important role in the success story of fluid milk products as well as most of the manufactured milk products. This same asset can be enjoyed by the whey industry if we meet the challenge to obtain and maintain the highest quality possible. Utilization of whey products in food formulations will continue to grow only if we can build the confidence of the user by providing him with a high-quality product. This is possible only if the quality of the fluid whey is maintained from cheese vat to final processing. The cheese industry plays a vital role in this area and must fully understand its responsibility in quality preservation if it expects the whey industry to successfully market this byproduct.

Another challenge facing the whey industry is the processing and marketing of the large quantity of cottage cheese whey that is now being disposed of by means other than processing. More stringent environmental regulations and the increasing load on many existing municipal sewage treatment plants are creating a serious problem in the cottage cheese industry. The problem is ... whey disposal. Many cottage cheese manufacturers, because of their size, are in a disadvantageous position in whey disposal. Their volume is too small to justify the installation of disposal or processing equipment, and at the same time municipal sewage plants are refusing to treat their whey because of maximum loading on their plants. This set of circumstances will tend to create fewer and larger cottage cheese manufacturers just as it has in the case of other cheeses. The remaining large cottage cheese manufacturers will more than likely decide on processing as the most economical means of dealing with their whey.

Processing techniques for handling cottage cheese whey are continually being improved, but additional work needs to be done. The most pressing need in this area is the development of products and markets for the utilization of cottage cheese whey. We will hear later in the program about some product development work being done in this area.

In the area of product and market development, considerable effort must be directed toward increasing the utilization of whey in human food formulations. Of about 800 million pounds of dry whey being processed, only about 400 million pounds are being used in food products.

Part of the reluctance to accept whey as a food ingredient is the image associated with it ever since the first cheese curds were made. Whey has been considered by many as animal feed.

This is the same situation that the nonfat dry milk industry faced about 30 years ago. Prior to 1944, nonfat dry milk was referred to as dried skimmilk. At that time, skimmilk carried much the same image as whey. As a matter of fact, its major outlets were for animal feed.

Then in 1944, its name was changed from skimmilk to nonfat dry milk. Within ten years after changing its name, human usage of this product increased from 500 million pounds to 1.3 billion pounds. Within 20 years, in 1964, human food utilization of nonfat dry milk increased to 2.1 billion pounds.

There is no doubt that more efficient processing techniques, improved quality, and aggressive marketing played a role. But I suspect the change in name improved the image of this product and generated a higher level of acceptance for use of nonfat dry milk in human food.

It was suggested at the last whey conference that consideration might be given to changing the name of dry whey as a means of erasing the image with which it has been burdened. I think we should take a hard look at the possible merits of this suggestion, although to change the name now may be more difficult than it would have been years ago.

The outlook is not all that bleak for higher utilization of whey in food formulations. There is considerable interest by some user groups in the development of a Grade A whey. This would be whey from a cheese manufacturer making his cheese from Grade A milk. The rapid conversion from manufacturing grade milk to Grade A milk in the major cheese-producing areas might well make available considerable quantities of whey that would qualify for such a designation. However, the cheese manufacturer and the whey processor will have to be willing to meet the additional standards and processing requirements established by Grade A regulatory agencies. It would appear that a Grade A whey would open up markets that are not now available to dry whey.

I think the whey industry can look forward with optimism to the development of hydrolyzed lactose products. Several speakers on the program will be discussing the problems and the opportunities in this area of product application. With the price of sucrose reaching unprecedented levels, whey products made naturally sweeter through lactose modification should be appealing, and hydrolyzed lactose should find widespread application as a competitive sweetening agent. Laboratory development is the first step. The next challenge is for the whey processor to transform laboratory results into profitable products of commerce.

Our problems are still numerous and the challenges loom large. We have a long road to travel before we convert all of our problems to profits.

PROCESSING MODIFIED WHEY PRODUCTS

D. A. GRINDSTAFF

Stauffer Chemical Company
Rochester, MN 55901

The whey industry has an interesting problem, or opportunity, facing it regarding whey utilization. As an indication of the magnitude of this problem, slightly over 29 billion pounds of whey was produced in 1972 and the projections for 1980 are somewhere between 36 billion and 41 billion pounds.

At the 1973 WPI meeting, information was given that in 1972 less than 50 percent of the total available whey solids were utilized. Utilization figures for 1973 did not show a substantial increase. But yesterday, WPI handed out some updated figures which indicated that in 1972 approximately 53 percent of the whey solids were utilized, and the figures were increased for 1973 to 56 percent.

But with increasing production of whey there will be additional pressures to seek the best procedures available for its utilization. This will involve producing increasing quantities of modified whey products using existing and developing technology.

Whey has many physical and chemical properties that make it of interest to the food processing industry. But its major advantage is the nutritional quality of its proteins. This feature alone makes whey an attractive product to the industry as a nutritional supplement to other protein systems.

A considerable technology for utilizing whey is available within the industry. The primary area is in the drying of sweet whey and sweet whey blends. There is a large market for these products, and with an increasing demand by the Government for whey-soy beverage products, the utilization of sweet whey will increase measurably.

There is also increased interest in dried acid whey and markets for this product are developing.

Five processes for producing modified whey products have been available to the industry for years: heat coagulation, electrodialysis, polyphosphate precipitation, gel filtration, and ultrafiltration. Table I shows the compositional analysis of the products produced by these methods.

TABLE I.--Preparation of modified whey products.

Process	Composition (percent)			
	Protein	Lactose	Ash	Fat
Heating	80	5	4-5	5
Electrodialysis	20-35	45-60	3-18	2-4
Polyphosphate	55-60	18-22	10-18	6-9
Gel filtration	15-75	10-45	3-26	0.1-4
Ultrafiltration	30-76	6-55	3-12	1-5

The precipitation process is going to be discussed by the next speaker, and I gather this was discussed in an earlier paper today. In addition, Alfa-Laval has a proprietary process, Centri-Whey, for recovering the proteins from cottage cheese whey by heat precipitation and recycling them back to the cottage cheese product.

The next process, electrodialysis, has been utilized by Foremost and Purity in the manufacture of their products for a number of years. They have been producing a demineralized whey and a partially demineralized, partially delactosed whey. Two new plants are to go on stream in Ireland this year using Ionic's electrodialysis process for the straight demineralization of whey.

The third process is a polyphosphate precipitation procedure which is being utilized by Borden to make a product called Protolac. In addition, Dr. Pallansch and his group in the last few years have done some work in combining phosphate precipitation with gel filtration and ultrafiltration processing to produce very high-quality whey protein concentrates.

The final two processes, gel filtration and ultrafiltration, I would like to spend a little more time on, primarily because of our interest in them at Stauffer.

The gel process can be characterized as the reverse of filtration. In filtration the medium retains the larger particles, or molecules, as in ultrafiltration. But in gel filtration the small molecules are retained while the larger ones pass through the void spaces in the packed bed. As soon as the gel system is charged with the mixed feed, with its relatively high-molecular-weight protein and low-molecular-weight salt and lactose, the protein starts to separate from the mineral constituents. The salt and lactose molecules enter the interstices of the gel bead, while the protein molecules remain in the void volume portion of the bed because they are too large to penetrate the gel particle. Thus the protein is eluted from the bed, while salt and lactose are retained. Figure 1 is an elution diagram for the gel filtration

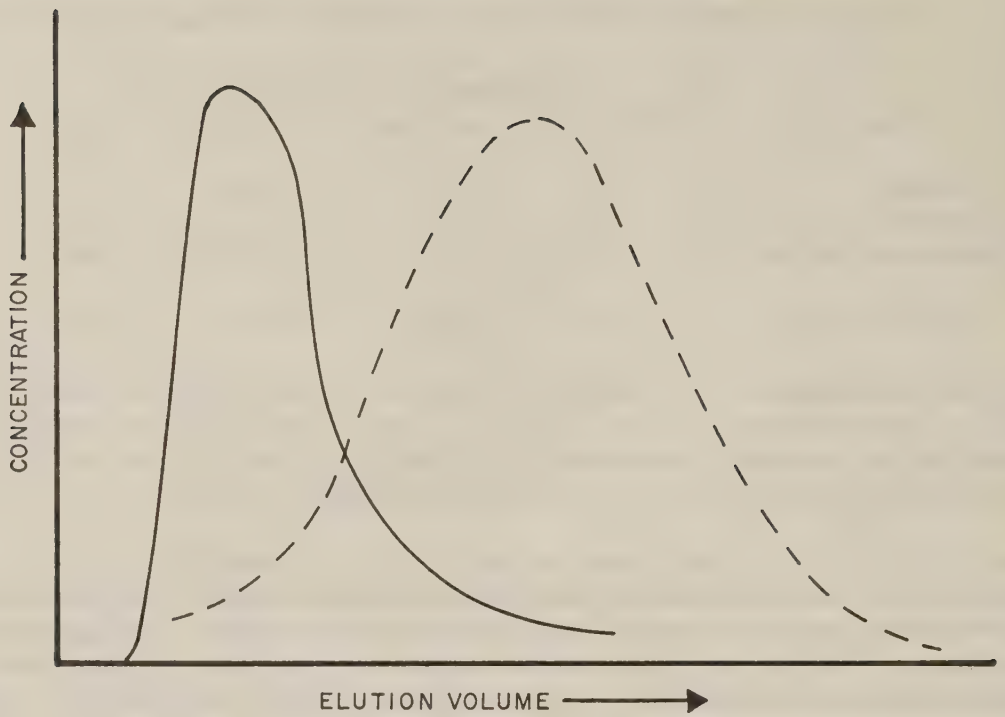


Figure 1.--Elution diagram for gel filtration of partially delactosed whey.

of partially delactosed whey. The solid line shows the high-molecular-weight protein eluting from the packed bed. The dashed line shows the elution of the low-molecular-weight materials--lactose, ash, and nonprotein nitrogen.

The separations can be made more definitive by either slower elution rates or deeper beds. If you speed up the elution rate and overlap the curves, you can obtain a product of any quality from 80 percent protein down by adjusting the point at which you make your chromatographic cut. At Rochester we are producing a product which is basically 50 percent protein and also a low-molecular-weight product we call Enrex which runs about 15 percent protein and contains much of the residual ash and lactose.

Figure 2 shows a flow sheet of the process currently practiced at Rochester with one minor modification. Instead of spray drying, the lactose is dried using a fluid-bed unit.

The whey is first pretreated, then concentrated in a multi-effect evaporator. The lactose is crystallized in batch crystallizers, then separated, and the mother liquor is introduced to the gel operation. The proper cuts are made on the protein and the salt fractions. These come out somewhat diluted. They are subsequently concentrated and spray dried.

Figure 3 shows the schematic of the process as it exists. The pretreatment process involves clarification operations which we will get into a little later in more detail. The clarification is to remove the suspended solids which may interfere with the lactose crystallization and also with the gel filtration. The process proceeds to multi-effect evaporation, crystallization

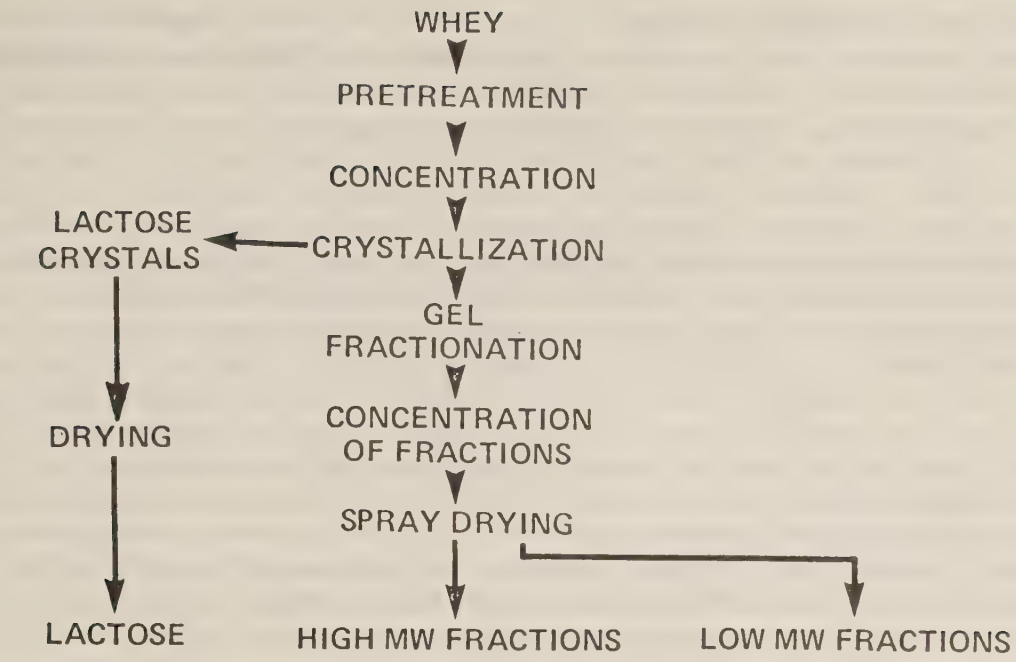


Figure 2.--Gel filtration process for whey fractionation.

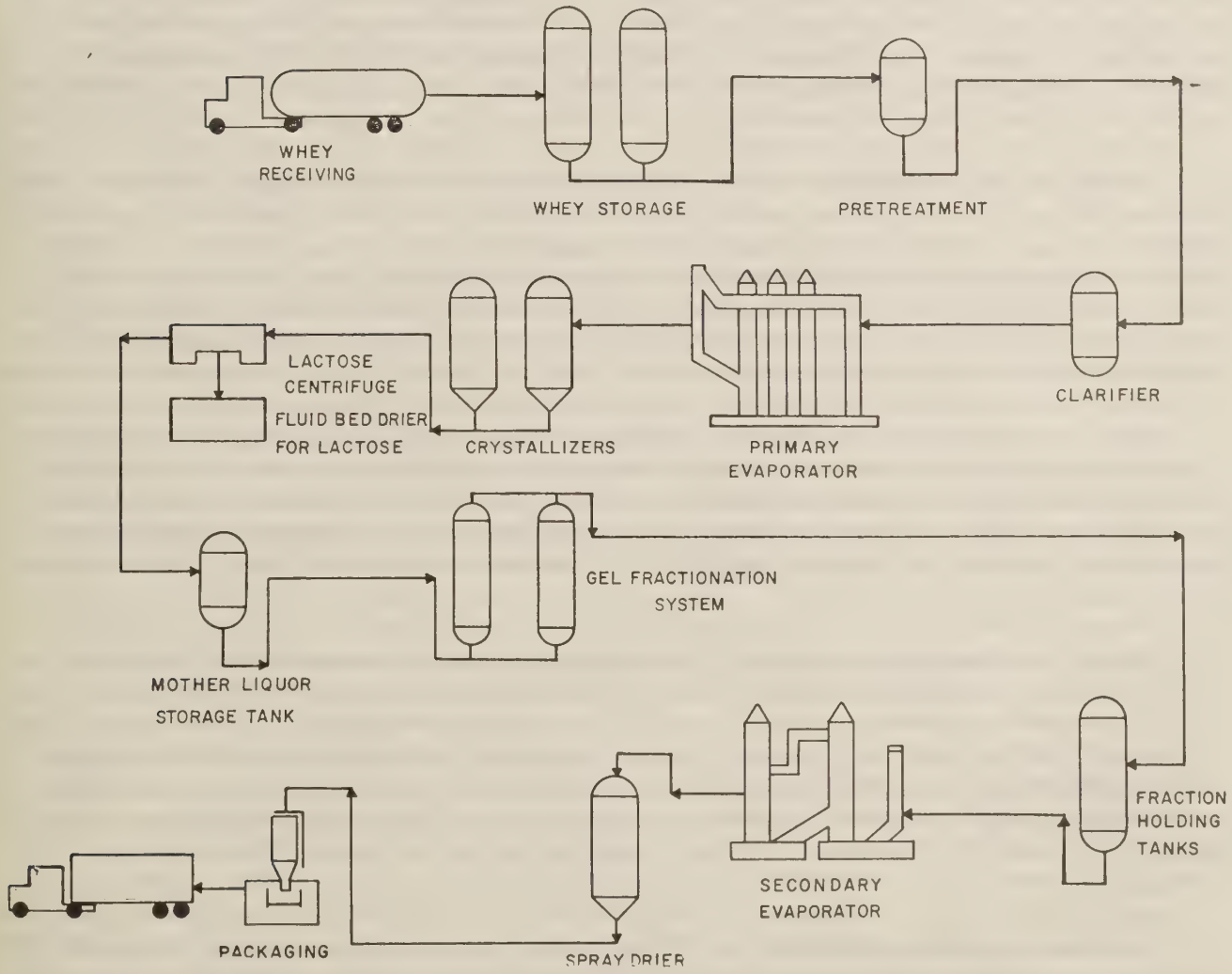


Figure 3.--Schematic description of gel filtration process for whey fractionation.

and separation of the lactose, and gel filtration. The protein fractions and the ash fractions are segregated in separate holding tanks and then pasteurized, concentrated, and spray dried. The desired bacteriological control is achieved by pasteurization prior to concentration and spray drying.

The process has had some problems in getting implemented. These were involved primarily with the gel operation itself. How do you clean a chromatographic column? How do you prevent plugging, channelling? These are strictly operational problems which had to be resolved within the production facility itself.

The next process I want to talk about a little bit is ultrafiltration. Ultrafiltration of whey to produce whey protein concentrates has received considerable attention over the last few years. But to my knowledge only two plants in the United States are currently making production quantities of the material. Abcor and Crowley indicate the system at La Fargeville, N.Y., is operating daily and producing an acceptable protein product.

The second production plant came on stream this year at Lynn, Wisconsin, and is being operated by Lynn Proteins. It utilizes a spiral wound membrane installed in a system designed and built by Frank Thomas. The system is producing a nonfat milk replacer, with a protein level of approximately 35 percent. The protein concentrate from the plant is being utilized in both animal and human food products.

Although the ultrafiltration process has been proved (and I am sure the manufacturers of the system would guarantee that) the whey industry has been somewhat reluctant to move forward with commercializing the process. Now there are many possible reasons for this, some of which are as follows: One, the price of dried whey has been increasing and there has been less of an incentive to increase the cost of processing by increasing the number of operating steps. Ultrafiltration is not necessarily a cheap process.

Two, the capital cost of the ultrafiltration system is high and there is a question regarding membrane life. Membrane costs may represent a substantial portion of the operating cost of the ultrafiltration plant. To give again the manufacturers their due, they are involved in continuing programs to upgrade the quality of the product to ensure better membrane life and membrane stability.

Three, the market potential for the whey protein concentrate is still being defined, and considerable work still needs to be done in this area.

Four, there is a big question as to whether the systems can be effectively cleaned and sanitized, using either standard dairy practices or new technology being evolved either by the user or the producing industry. This is possibly one of the most serious problems with the ultrafiltration system.

Another potential problem is the way the regulatory agencies view the membrane equipment. The USDA has reviewed several of the systems and has

made comments to the suppliers. At least one of the suppliers has approached the FDA for potential approval of the system.

Finally, we come to another big problem with the system. After you have taken out the protein in the form of the ultrafiltrate on the retentate stream, you are left with the permeate stream containing lactose. This is high in ash. What can you do with this stream? The pat answer is that you can produce a high-quality, edible grade lactose by concentrating and crystallizing it. But you are still left with a byproduct stream. I will call it, for lack of a better nomenclature, delactosed, deproteinized whey. It is high in ash, somewhere around 30 or 40 percent; it is high in lactose, 35 or 45 percent; and, depending on the selectivity of the membrane, it has a protein level of about 8 to 10 percent.

This is not an easy product to dispose of. You heard Mr. Hargrove this afternoon outline another process which would be the concentration and production of salt blocks out of permeate. This is a possibility. There is a question of how much of the permeate of the lactose stream could be utilized in this type of application.

Another possibility would be implementation of a process that the EPA is supporting at Amber Laboratories in Juneau, Wisconsin. I believe they have been granted a quarter of a million dollars to study fermentation of acid whey. The technology evolved in this process could potentially be utilized in converting the lactose to animal feed, or possibly even to an edible-grade product. Again this is something that needs to be studied in more detail.

There are problems with the membrane separation equipment in ultrafiltration, gel filtration, or electrodialysis. The industry is beginning to recognize that whey may not be the best material to process with this molecular separation equipment. There is an increasing number of references in the technical and patent literature outlining various whey pretreatment processes. In addition, ultrafiltration equipment suppliers are now recommending additional whey processing steps prior to introducing the feed to the membrane. Initially, most pretreatment steps involve mechanical separation processes to remove cheese fines and/or whey cream. But more recent studies have outlined chemical and thermal processes to supplement this.

A patent granted about three years ago to Attebery describes a process for residual lipid removal from sweet whey. The procedure involves the addition of a divalent cation, calcium, to the whey and adjusting the pH to greater than 6 at a temperature below 140°F. During the neutralization or pH adjustment step, a lipid-containing precipitate is formed. This material is removed, leaving a lipid-free whey; the separated whey, according to the patent, can be more readily processed through membrane separation equipment.

A German company has recently been granted a patent on a direct acidification process. Again this is a pretreatment process. As it is outlined, the pH of the whey is adjusted to between 2.7 and 3.3 and heat treated prior to processing. The process has the advantage of operating at conditions

which minimize microbiological problems and improve operations with regard to membrane performance. There is lower ash retention under these conditions. And there is a potential of higher average permeation rates.
But depending on the porosity of the membrane, there is a potentially negative aspect, and that is, you may end up with higher losses in real protein since the protein is now no longer in an aggregated form.

A third process has been outlined in a recently granted U.S. patent for producing a heat- and acid-stable whey material using the molecular separation process. The key step in the process is the pretreatment procedure to remove calcium from the whey, mostly in the form of insoluble calcium phosphate. The process as described involves adjusting the pH of the whey, heating the neutralized whey, and centrifuging the heated whey to remove the insoluble materials. After cooling the supernatant, clarified whey can be processed with the molecular separation system either above or below the isoelectric point of the whey proteins. According to the patent, the process does several things. One, it pasteurizes the whey before introduction into the membrane equipment. This is a desired feature as far as the supplier is concerned. Two, it removes the calcium from the system mostly as an insoluble calcium phosphate. Three, it coagulates and removes the highly heat-sensitive globulin fraction and other insolubles such as fat and sediment. And lastly, the patent claims it forms a more heat-stable complex between the lactoglobulin fraction and the alpha-lactalbumin fraction.

Finally, a research group in Australia headed by Drs. Hayes, Dunkley and Muller at the Dairy Research Laboratory at Highett, Victoria, has been investigating methods of improving permeation rates of ultrafiltration systems by pretreatment. The studies indicate that a heat treatment followed by pH adjustment can substantially improve permeation rates of whey. They have worked with acid casein whey, particularly hydrochloric acid casein whey. They have also worked with cheddar whey. The process involves heating to 80 to 85^{o}C. for 15 seconds and adjusting the pH to the range of 5.2 to 5.9. The article claims improvements in permeation rates over processing at natural pH's of 100 percent in the case of acid whey and 50 percent in the case of cheddar whey. Additional work is being done in this area, and it is necessary.

The industry as a whole is evolving new processes to supplement existing processes in the utilization of whey and modified products. It is necessary that these programs continue at all levels--industrial, governmental, and university. It is also necessary that there be a continuing exchange of information between the groups to ensure development and implementation of the best procedures available for the processing of whey.

THE HEAT COAGULATION OF COTTAGE CHEESE WHEY PROTEINS AND THEIR INCORPORATION INTO MACARONI

H. I. SINNAMON*

Eastern Regional Research Center, ARS, USDA
Philadelphia, PA 19118

I am glad to be here today so that I can report to you on some rather promising results that have come out of our whey research program. When we began our work, we proposed to proceed along two lines. First, we planned to study the separation of whey into its components or fractions by various mass-transfer operations. Second, we intended to seek new uses for these fractions as well as for the whole whey. These two lines were not necessarily meant to be mutually supporting. As it worked out, they were, because the engineer doing the work on end-use found that he needed a fraction containing insoluble proteins. This need led us into heat coagulation.

The concept is quite simple. If whey is held at a high enough temperature for a sufficient period of time, some of its protein will coagulate. The amount that can be coagulated is dependent upon a time-temperature-pH relationship. At best, approximately 60 percent of the protein can be coagulated by heat.

The process presented here is the end product of efforts to improve upon heat-coagulation processes that have evolved through the years. Conventionally, heat coagulation has been carried out at 185 to 212°F., with a minimum holding time of 15 minutes. In our process we coagulate at 250°F, with a holding time of 8 minutes.

In all of our experiments we used cottage cheese whey. Though this type constitutes only about 20 percent of the whey produced in the United States, it is utilized to a lesser extent than sweet whey. Although we do plan to extend this work to sweet whey, for now, when we say "whey" we mean "cottage cheese whey."

Initial experiments showed that heat coagulation at 250°F gave somewhat greater recovery of protein than at higher or lower temperatures. We therefore conducted our detailed experiments at 250°F. Figure 1 gives data on the effects of pH on protein recovery. Heating was done in a laboratory autoclave. Total heat exposure was for 15 minutes, including 5 minutes for come-up and cooling times. The protein content of the liquid whey was determined by the Lowry method both before and after removal of the coagulated protein, and the difference reported as recovered protein. The results of the

*Coauthors of this paper: E. F. Schoppet, C. C. Panzer, F. B. Talley and N. C. Aceto

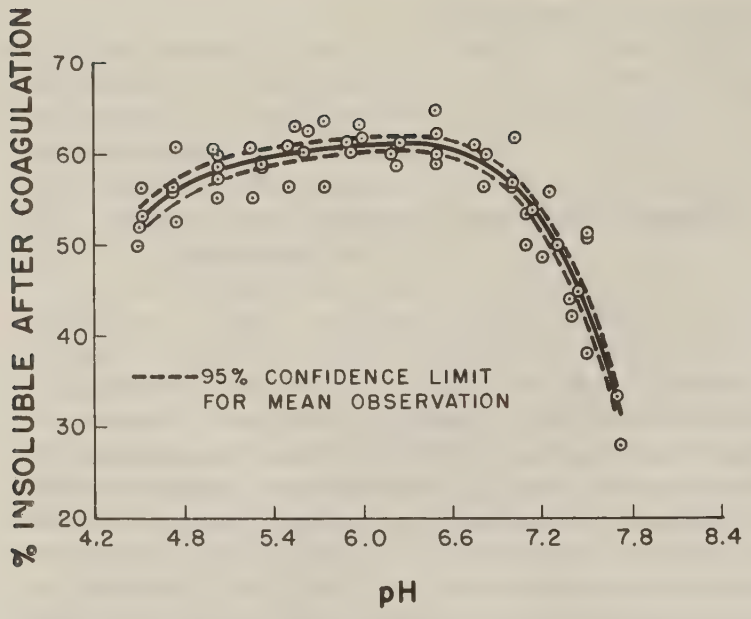


Figure 1.--Effect of pH on the amount of protein coagulated from cottage cheese whey after holding at 250°F. for 10 minutes in an autoclave.

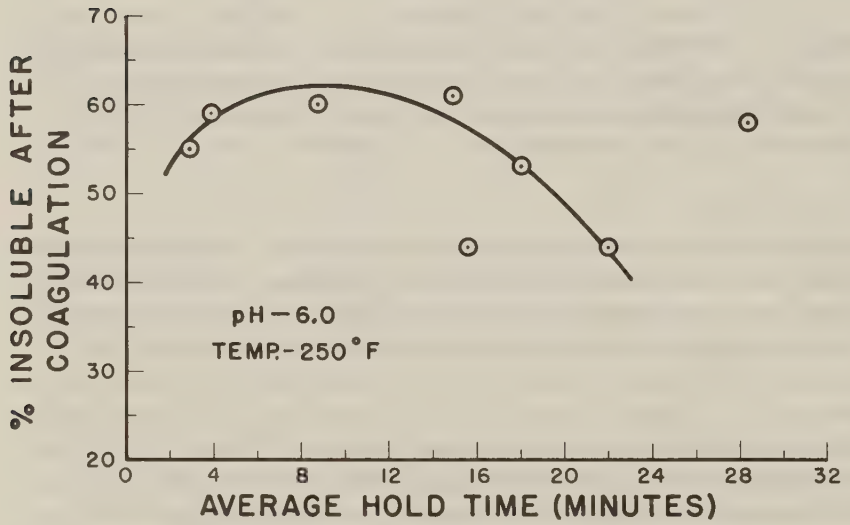


Figure 2.--Effect of average holding time in a back-mix reactor on the amount of protein coagulated from cottage cheese whey at 250°F. and a pH of 6.0.

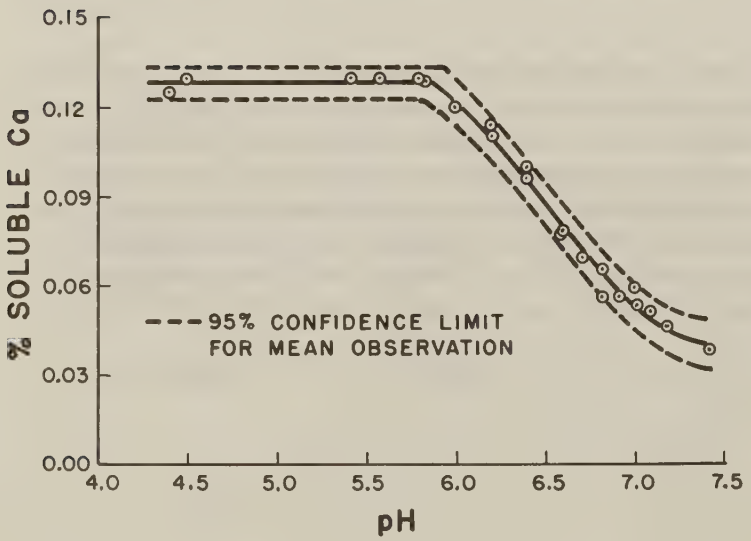


Figure 3.--Effect of pH on the solubility of calcium salts in cottage cheese whey at room temperature.

experiments show that at 250°F a maximum of about 60 percent of the crude protein in whey can be insolubilized by heat coagulation. This maximum occurs at a pH of about 6.0.

Experiments were then conducted in a back-mix reactor to determine the effect of holding time on the amount of protein coagulated at 250°F and a pH of 6.0. These results are given in Figure 2. You can see here that in a wide range of from about 4 to about 16 minutes the amount of protein precipitated is nearly independent of holding time. Since the curve for pH is similar to this, we have a process here where precise control is not essential. This should simplify the process design and operation.

Calcium salts in whey also can be insolubilized by pH change. Therefore, laboratory experiments were conducted to determine the amount of soluble calcium in whey as a function of pH. In these experiments at room temperature, whey samples were adjusted to various pH's from 4.5 to 7.2, and after filtering, the filtrates were analyzed for soluble calcium.

Figure 3 shows the effect of pH on calcium salt solubility. Ash is insolubilized in varying degrees by increasing the pH of whey above 5.8. As shown, insolubilization is substantially complete at pH 7.

Because of the insolubilization of calcium salts at the optimum pH for heat coagulation, a straight-forward process will result in a high ash content for the product. Under some circumstances high ash may be undesirable. Therefore, we developed two processes in our pilot plant as shown in Figure 4.

In the main scheme the whey was adjusted to the experimental pH with 3N sodium hydroxide, preheated to 140°F, and heated to coagulation temperature by direct steam injection. At this temperature the whey then flowed into a pressurized reaction vessel equipped with a centrifugal recirculation pump to promote mixing. It was held here for an average of 8 minutes. The coagulated whey slurry was then cooled to below 100°F and centrifuged. In the alternate scheme the coagulated whey slurry was adjusted to pH 4.6 with 3N acetic acid to redissolve the calcium salts before centrifugation.

TABLE I.--Composition of heat coagulated, high protein fractions from cottage cheese whey.

Type	Coag. pH	% Protein (MFB)	% Ash (MFB)	% Lactose (MFB)
Conventional - 95°C	6.0	65 to 70	20 to 25	10
High Temp. - 120°C	6.0	65 to 70	20 to 25	10
High Temp. Ash Resolubilized at pH 4.6	6.0	>85	<5	10

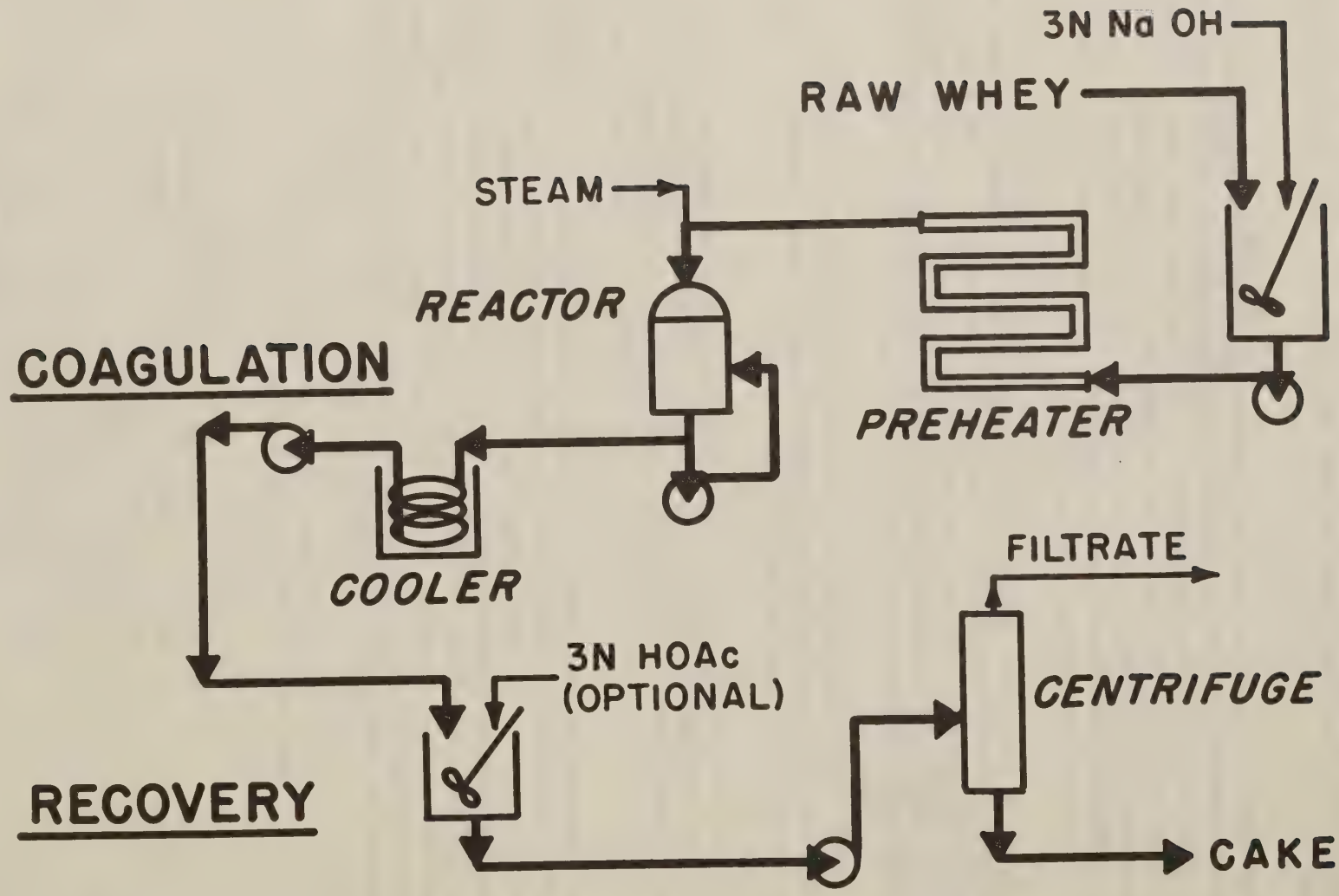


Figure 4.--Processes for preparing high-protein fractions from cottage cheese whey by heat coagulation.

Table I shows compositions of three products, illustrating how the ash content can be reduced by lowering the pH after coagulation. The "conventional" product and our high-temperature product have the same composition on a moisture free-basis--65 to 70 percent protein, 20 to 25 percent ash and 10 percent lactose--whereas the product in which the ash was "resolubilized" before centrifugation has a much higher concentration of proteins and a much lower ash content.

For the future we are evaluating spray, drum, freeze and cross-circulation air drying of the cake which contains only 35 percent solids when it comes from the centrifuge. We also plan to consider several proposals for treating the effluent from the centrifuge. Now let's turn to the end-use work.

As you know, whey proteins are highly nutritious. Our overall aim was to learn how to combine these high-protein fractions of whey with foods that are quite popular but generally lacking in protein nutrition. As an example of such foods, we took pasta products and studied the effect of adding these proteins to them as a means of raising their protein efficiency ratio (PER).

The criteria set for success of the pasta-enrichment research are shown as follows:

1. Pasta protein content increased to 20 percent
2. PER of product increased to at least 95 percent that of casein.
3. No change in pasta-making process.
4. Organoleptic properties of cooked product similar to conventional pasta.

The first two criteria were taken from the standards for protein content and nutritional quality of pasta products for a school lunch program. The third criterion--that enrichment shall not require modifications in the traditional pasta-making process--could be of critical importance, for people don't like to change a successful process. The fourth criterion is for the consuming public. We didn't want to have to "re-educate" the consumer to our product.

The basic idea of the research was to add sufficient amounts of various high-protein whey fractions to durum granular flour to bring the total protein content to 20 percent, make elbow macaroni; dry the pasta in a drying cycle, duplicating as closely as possible the conditions used commercially; and then test the product for various biological and organoleptic properties. The whey protein fractions used for enrichment are as follows:

Whey Protein Fraction	Approx. Protein Content
1. Commercial product	35 percent (soluble)
2. Commercial product	50 percent (soluble)
3. Industrial experimental product	70 percent (soluble)
4. Heat-coagulated experimental product	66 percent (insoluble)
5. Experimental byproduct	80 percent (insoluble)

Products 1 and 2 are items of commerce. Product 3 was available at the time of this study, but has since been taken from the market. Product 4 was our heat-coagulated protein that was not de-ashed. Product 5 is a byproduct of a process developed by our Dairy Laboratory.

Note that the products listed can be separated into two groups, those containing soluble proteins and those containing insoluble proteins. To achieve a level of 20 percent protein in pasta, products 1 and 2 would have to be added in the ratio of 5 and 2.2 pounds per 10 pounds of flour, respectively, whereas product 5 would require only 1 pound per 10 pounds of flour. Obviously, the ideal would be a whey fraction that is 100 percent protein. We made our experimental products on a Demaco model S-25 laboratory press with an elbow macaroni die. We dried them in a small Hotpack environmental chamber.

Figure 5 is a schematic drawing of the mixing chamber of the laboratory pasta press, looking down. Flour and protein fractions are blended before going to the press. The oval at the top of the drawing represents the area where the dry feed mixture is metered into the mixing chamber. Water is metered in just beyond the flour input. Solids and water are mixed thoroughly as they move along the chamber to the discharge port. The wetted, mixed feed then drops into a screw that carries it to a forming die. It was here in the mixing section that our first problems developed. We found that when we used whey fractions containing soluble protein, the blends became very sticky as mixing progressed. They adhered to the surfaces of the mixer and quickly formed a permanent plug over the mixer outlet. As the outlet was closed off, production of pasta stopped.

In Figure 6 we show a cross section of the important elements of the laboratory pasta press. The point marked "barrel water input" shows our effort to keep the mixer outlet from plugging when soluble whey proteins were used for enrichment. A hole was drilled through the barrel at a point about an inch below the mixer outlet so that water could be injected directly onto the screw. This permitted us to obtain some product for test, but we could not operate long enough for the solution to be considered satisfactory. At the very best, if we were to use a soluble protein, a major departure would be required from traditional processing. Since this would violate the criterion we had set up of avoiding processing modification, we abandoned further work with soluble proteins. We had no trouble, however, with the insoluble protein fractions, both of which we used to make several enriched products for testing. Analyses showed that the added whey protein fractions retained their amino acid balance during the manufacturing, drying, and cooking of the pasta. We also found that leaching of solids during cooking was negligible.

The added whey proteins substantially upgraded the nutritive value of the pasta. Common macaroni, which has a protein content of about 13 percent, was enriched with the whey fractions to bring its protein content up to 20 percent. PER values were obtained through animal feeding tests on the whey protein fractions alone and on macaroni enriched with them. The data obtained in these experiments are as follows:

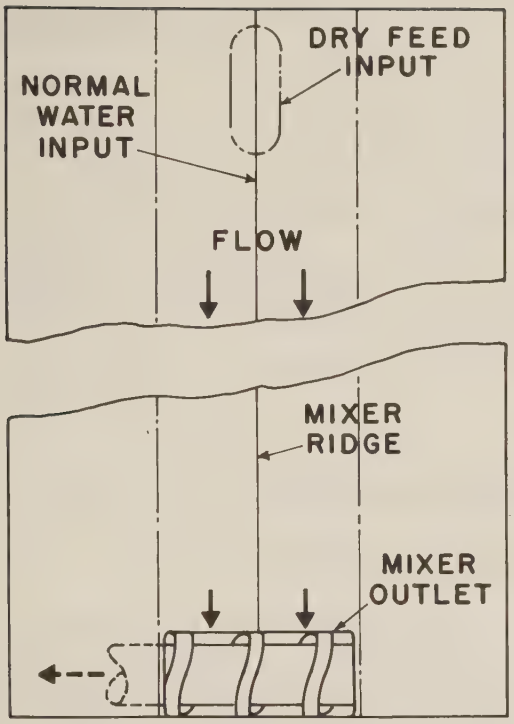


Figure 5.--Schematic of laboratory macaroni press (top view).

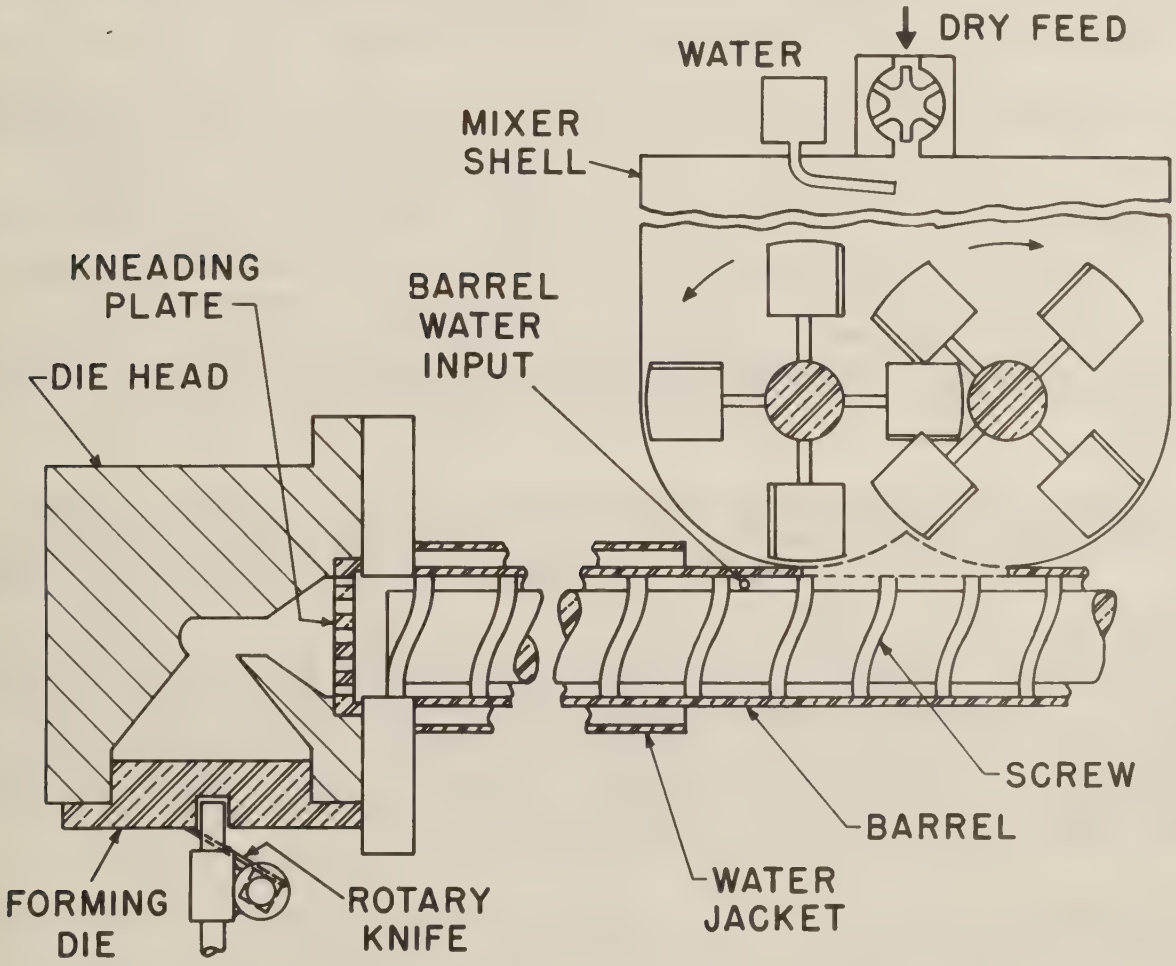


Figure 6.--Schematic of laboratory macaroni press (side view).

Dietary Source of Protein	PER Corrected
Casein control	2.50
Common macaroni	0.70
Heat-coagulated insoluble protein (66 percent)	
Protein alone	3.05
Macaroni enriched with protein	2.41*
Industrial experimental soluble protein (70 percent)	
Protein alone	3.05
Macaroni enriched with protein	2.31
Macaroni enriched with soluble protein (50 percent)	2.06

*Not significantly different from casein (p=0.05)

It is notable that the heat-coagulated insoluble protein brought the PER of the macaroni up to a point not significantly different from that of the protein control casein. These PER data must be considered preliminary, pending the completion of confirming tests now in progress on common macaroni, the heat-coagulated protein, and macaroni enriched with it.

Texture profiles were run on common pasta and on the protein-enriched samples, and differences were found. Some of the differences could be overcome by changing the cooking time, but they could not be completely eliminated. However, taste tests showed that these texture differences did not result in an unacceptable product. In these tests, trained tasters scored samples of cooked macaroni, both unenriched and enriched with two of the whey protein fractions, the heat-coagulated insoluble fraction and the experimental insoluble fraction obtained as a byproduct of a process developed by our Dairy Laboratory. The tasters assigned a score to each sample in accordance with a 9-point hedonic scale, with any score not less than 5 being considered acceptable.

The results of these taste tests are given in Table II. The "standard" product (no enrichment) was made from the same durum flour used for the other samples. The samples were served to the judges warm. They were served plain (without sauce), with a cheese sauce, and with a tomato sauce. The results show that the tasters rather consistently preferred the plain standard pasta over the enriched, but virtually all of the scores were above the acceptable level of 5. The flavor and texture differences between the unenriched and the enriched products were less marked when the sauces were added to the pasta after cooking. In test results not shown in Table II, these enriched samples were consistently preferred over a sample of macaroni now commercially available at retail that is enriched to 20 percent protein.

In summary, we believe that this work has shown that a whey protein fraction of high nutritive value can be obtained by a simple process and that this protein fraction can enrich the nutritive value of macaroni products quite

significantly without reducing the gustatory quality of the macaroni below the acceptable level.

TABLE II.--Results of taste-panel tests of standard pasta and pasta enriched with whey protein fractions (9-point hedonic scale*)

Test conditions	Standard (no enrichment)	Enriched (heat-coagulated)	Enriched (insol. byproduct)
Plain	6.27 (a)	5.07 (b)	-
Plain	6.62 (ab)	-	5.77 (ab)
Plain	7.33 (a)	5.08 (c)	6.00 (b)
Plain	7.25 (a)	4.25 (c)	5.25 (b)
Cheese sauce	7.25 (a)	5.42 (b)	-
Cheese sauce	6.81 (ab)	-	6.56 (ab)
Cheese sauce	6.43 (abc)	6.64 (abc)	6.86 (abc)
Tomato sauce	7.15 (abc)	6.76 (abc)	6.86 (abc)
Tomato sauce	7.08 (a)	-	5.38 (b)

*Reading across, data followed by the same letter in parentheses are not significantly different at the 95 percent confidence level.

This work also suggests that high-protein fractions from cheese whey can be used to upgrade the nutritive value of other foods. Work along this line will be pursued in our Laboratory.

We thank Virginia Holsinger of the Dairy Laboratory, Eastern Regional Research Center, for providing the insoluble whey from her process, Eileen Skelly of the Engineering and Development Laboratory for running the chemical analyses, Ed Kalan of the Plant Products Laboratory for conducting the amino acid analyses; and Al Booth of the Western Regional Research Center for data on PER testing. We are also indebted to the Lehigh Valley Dairy of Allentown, Pennsylvania, for providing the whey used in all of this work.

PRODUCTS FROM LACTASE-TREATED MILK AND WHEY

V. H. HOLSINGER AND E. J. GUY

Eastern Regional Research Center, ARS, USDA
Philadelphia, PA 19118

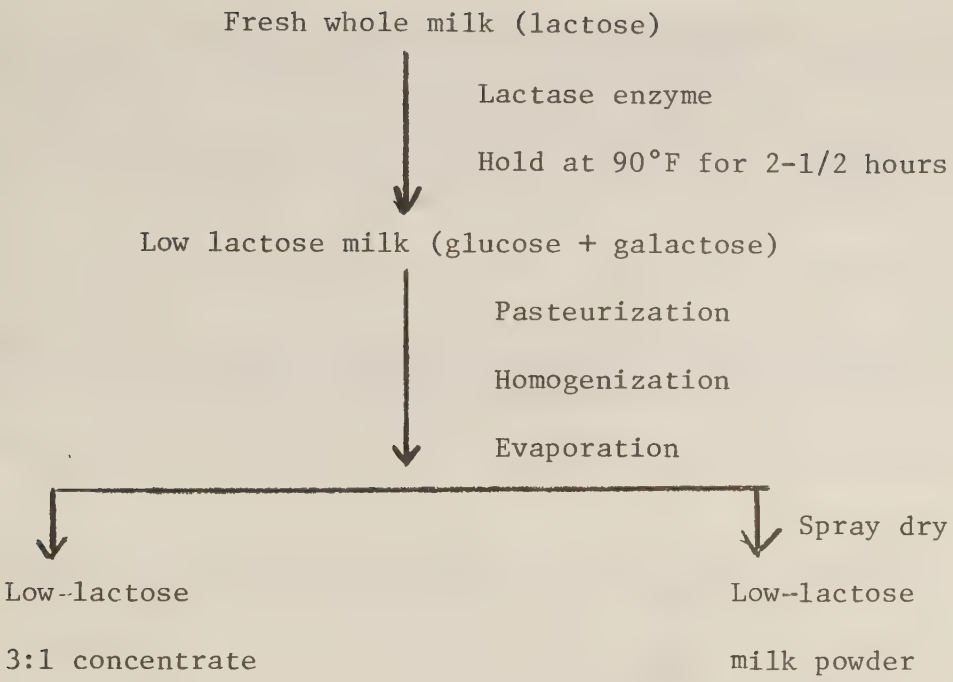
The mystery as to why large numbers of people throughout the world reject milk as a food for adults has been partially solved. It has been found that a significant percentage of members of non-Caucasian races cannot properly digest milk due to a deficiency of lactase enzyme in their gastric tract. The few populations where lactose tolerance exceeds intolerance include most western Europeans and white Americans. In the late 1960's, Paige (4), using a grant from USDA, conclusively demonstrated a correlation between lactase deficiency and milk rejection in black school children in Baltimore. Work then began to seek a means of rectifying the situation.

The most obvious approach to the development of dairy products suitable for consumption by lactase-deficient people is to employ lactase from non-human sources to hydrolyze the lactose into its component digestible monosaccharides glucose and galactose prior to product manufacture. A study of this approach has been recommended by the Ad Hoc Committee of the Protein Advisory Group of the United Nations System in the research recommendations section of its report on milk intolerance. (7).

Using this approach in our research, we have successfully prepared a variety of milk products in which the lactose content was markedly reduced by use of a commercially available lactase during processing.

The enzyme used in these studies was isolated from the yeast *Saccharomyces lactis* in the form of a colorless, free-flowing powder by Gist-Brocade, Delft, the Netherlands, and made available to us by the Enzyme Development Corporation, New York, N.Y.

We used a batch process to produce a variety of dairy products containing 87-94 percent of the lactose present in hydrolyzed form. Fresh whole or skim-milk was preheated to 88-90°F (33°C) and treated with the desired amount of enzyme, usually 300 ppm. After holding for 2.5 hours the milk was ready to be processed further. A flow diagram of the general process is as follows:



A listing of the products produced on a pilot-plant scale in our research facilities in Washington, D.C., is shown in Table I. These include fluid milk, 3:1 concentrates, milk powders, ice cream, whey concentrates and whey-soy drink. After straightening out a few problems in production methodology, the physical and organoleptic properties of these products were investigated.

TABLE I.--Characteristics of low-lactose products manufactured in the Dairy Products Laboratory pilot plant.

Product	Comments
1. Fluid pasteruized milk	Sweeter than control milk
2. Frozen 3:1 concentrates	Improved physical stability during 6 months' storage
3. Foam spray dried whole milk powder	Tendency to stick on overheated metal surfaces of dryer
4. Foam spray dried nonfat milk powder	
5. Ice cream	Reduced development of sandiness during storage
6. Cheese whey concentrates	Noncrystallizing fluid ice cream ingredient
7. Whey-soy drink	Sweeter than control

Trouble was immediately encountered in defining the taste of the lastase-treated products. Data given in a 1973 publication by researchers at Cornell University (1) showed that judges using the ADSA score card graded pasteurized milk the same for taste regardless of the amount of lactose split by the added enzyme. This was done in spite of the judges' indications that lactose hydrolysis caused a marked change in the intensity of sweet flavor.

Our own taste panel reacted quite differently, as shown in Table II. The figures show a definite reciprocal relationship between the amount of hydrolyzed lactose in the product and the flavor score. Closer examination of the judges' response showed that marked sweetness was often considered to be a "foreign" flavor and the product was scored down accordingly. We agree with the Cornell researchers, however, that the only organoleptic change noted in fluid milk during lactose hydrolysis was a change in sweetness.

TABLE II.--Dairy Products Laboratory flavor score results from lactase-treated pasteurized whole milk.

Sample	Flavor Score
Control	37.0
30 percent Lactose Hydrolyzed	37.0
60 percent Lactose Hydrolyzed	36.7
90 percent Lactose Hydrolyzed	36.2

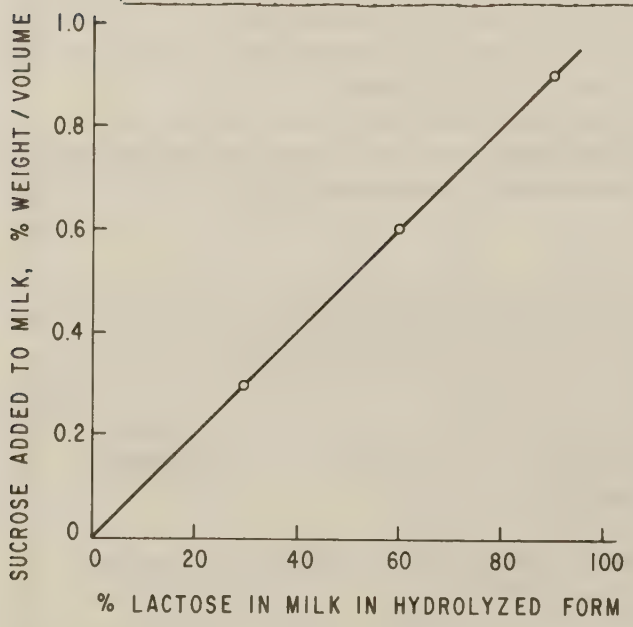


Figure 1.--Sucrose equivalence of hydrolyzed lactose.

Since milk products containing hydrolyzed lactose are characterized by sweetness, we attempted to develop an objective sweetness scale which would simplify reporting the organoleptic changes caused by lactase activity. The key feature of this system, as shown in Figure 1, is the fact that the results of lactase action can be equated with the flavor changes associated with the addition of sucrose.

A very real question is, of course, "How acceptable to the consumer is the increased sweetness produced by lactase action in milk?" Some recent work by Paige (3) has shown that whole milk containing 90 percent of its lactose

in hydrolyzed form was highly acceptable to Negro adolescents given an 8-oz. serving after an all-night fast. This age bracket represents one of the target groups where availability of lactase-treated milk would be beneficial. As shown in Table III, 56 percent of the respondents reported the 90 percent lactose-hydrolyzed milk to be sweeter than the control milk. Only one of the 27 youngsters found the milk to be unacceptable; all the others stated they liked the milk and would drink it.

TABLE III.--Reaction of Negro adolescents to sweetness of whole milk with different degrees of lactose hydrolysis.[a]

Comment	Percentage of responses (27 subjects)		
	Control	50 percent lactose hydrolyzed	90 percent lactose hydrolyzed
Sweeter than milk	12	18	56
Just like milk	28	52	--

[a]Reference (3)

The availability of this active and effective enzyme has allowed us to study the properties of a variety of dairy products. Some of the observations made to date have surprised us and some were anticipated.

We were chagrined to find that a frozen 3:1 pasteurized whole milk concentrate containing 90 percent of its lactose in hydrolyzed form thickened and coagulated during storage. An early paper by Tumerman et al. (10) had led us to believe that lactose hydrolysis would lead to the physical stability of frozen concentrates during storage. Figure 2 shows changes in viscosity of pasteurized whole milk concentrates during frozen storage. The control with no lactase treatment coagulated after 3 months of storage. After 4 months, the concentrate with 90 percent of its lactose in hydrolyzed form contained coagulated proteins that were visible when the product was thawed. Since frozen concentrated milk has always been considered a desirable product, we continued research in this area. Careful rereading of Tumerman's paper showed that the milks used in that research were heated above pasteurization requirements. When we post-heated the concentrates for 30 minutes at 71°C after canning, we obtained the results shown in the lowest curve in Figure 2. After 9 months of storage the post-heated lactase-treated concentrates showed only a moderate viscosity rise with no evidence of coagulation. After 10 months, the samples were organoleptically evaluated by trained dairy products judges.

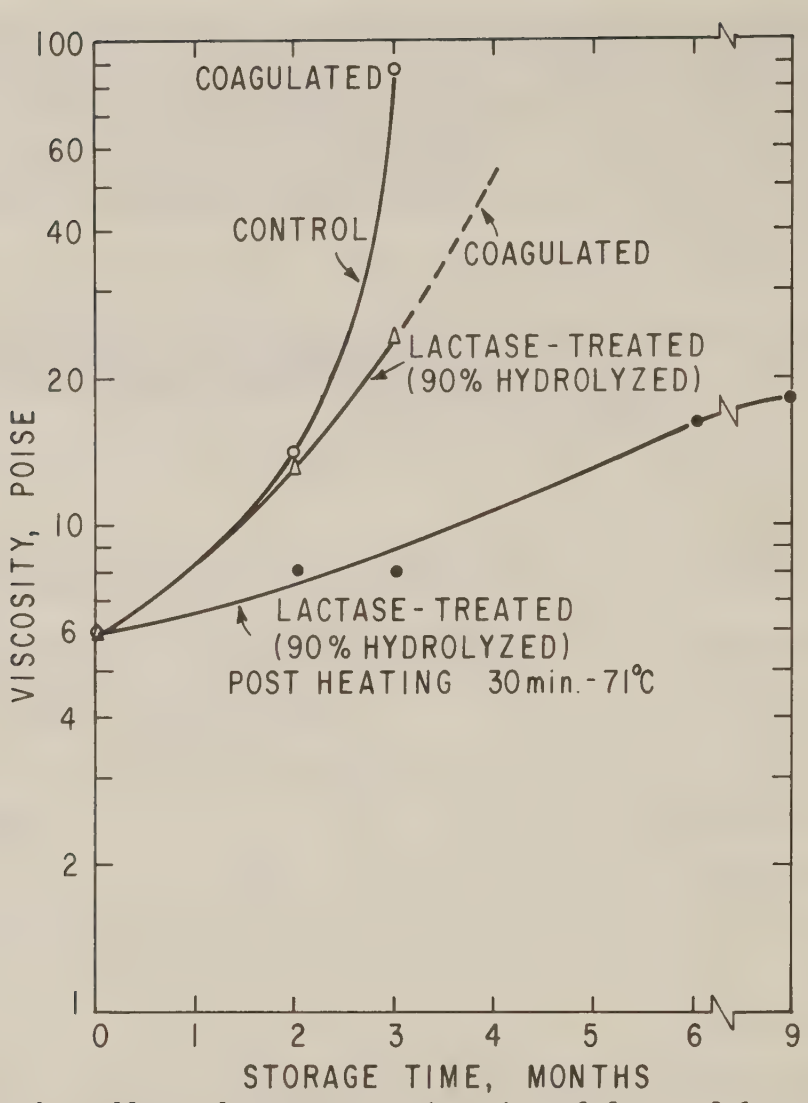


Figure 2.--Effect of storage on viscosity of frozen 3:1 pasteurized whole milk concentrates.

Flavor scores given to the reconstituted concentrate with 90 percent of its lactose hydrolyzed were not significantly different from scores given to a fresh whole milk control with sucrose added.

As anticipated, some trouble was encountered in the manufacture of milk powder containing most of its lactose in the split form. Lactase-treated whole milk powder was readily spray-dried but skimmilk powder had a tendency to stick to the hot metal surfaces of our spray dryer.

In order to control the spray-drying process we studied the "sticking" properties of low-lactose skimmilk powder. Using our Mark I "stickometer," a schematic drawing of which is in the Proceedings of the 1972 Whey Conference (5), we found the "sticking temperatures" of low-lactose skimmilk powder to be considerably lower than that of regular skimmilk powder at comparable moisture content. The results are summarized in Table IV.

Ideally, the dryer used to dehydrate lactase-treated skimmilk should have the surfaces of the powder-collecting apparatus held at temperatures below 60°C. Rapid cooling of the powder after collection is also recommended. Even though

our spray dryer is old and relatively inflexible, we have been able to reduce its operating temperature to the point where it can be demonstrated that practice agrees with theory.

TABLE IV.--"Sticking temperatures" of low lactose foam spray-dried nonfat milk powder.

Sample	Lactose Hydrolyzed (%)	Sticky Point (°C)
Control	0	75.4
Low-Lactose A	80	59.2
Low-Lactose B	87	64.6

The decrease in the available milk supply has resulted in increased utilization of whey in many foods. We have investigated the properties of lactase-treated sweet whey and cottage cheese whey neutralized to pH 6.6 prior to lactase treatment. To my knowledge no one has yet successfully spray-dried whey with 90 percent of its lactose in hydrolyzed form. However, because the crystallization characteristics are altered by lactose hydrolysis, such wheys may be readily condensed to noncrystallizing high-solids syrups which should find a variety of uses in the food trade.

Lactase-treated fluid whey can be used in the manufacture of ice cream. Although use of improved stabilizers has eliminated sandiness as a problem in present-day ice creams, our studies have demonstrated that lactose crystallization is retarded in ice cream made with lactase-treated serum solids when a stabilizer-modified formula was employed.

Ice cream mixes were made according to the following formulation:

Sucrose	13.5 or 15 percent
Milk Fat	12 percent
Serum Solids	11 percent
Gelatin - 270 bloom	0.3 percent
Vanilla Extract	0.5 percent

Gelatin, an accepted stabilizer, which does not permit sandiness to develop, was added to impart a smooth texture to the ice cream. Because the lactose hydrolysis increased the sweetness, sucrose levels could be reduced by 10 percent when lactase-treated serum solids were employed. In view of recent

prices of industrial sucrose, this could result in a monetary saving.

Table V shows how the texture of ice cream was affected when 25 percent of the total serum solids in the mix was contributed by lactase-treated whey solids--either sweet or neutralized cottage cheese whey. The texture scores shown, on the 9-point hedonic scale of Peryam and Pilgrim (6), are those for the experimental ice creams and for control samples made with all skimmilk solids. After 11 weeks of storage, no sandiness has developed in either ice

TABLE V.--Texture scores of ice cream containing 25 percent lactase-treated whey after storage at 13°C.

Sample	Hedonic rating for texture		
	Stored 2 weeks	Stored 6 weeks	Stored 11 weeks
Skimmilk control	7.8	6.0*	3.1*
25 percent of serum solids replaced by:			
Sweet whey solids	7.1	6.7	6.8
Neutralized cottage cheese whey solids	7.0	6.8	6.9

*Significantly lower than 2-week score.

cream containing lactase-treated whey. Our studies have also shown that the decrease in caloric density, due to the reduction in the quantity of sucrose used, did not alter the acceptability of the ice creams.

Whey-soy drink, the beverage powder made to order for use as a food supplement for preschool children in developing countries, has been extensively described to you by Dr. Pallansch. This product has also been proposed as a food supplement for pregnant and lactating women, particularly in emergency feeding situations. Although intolerance to the lactose present in whey-soy drink has not been a problem with young children, we thought that difficulties might arise with their mothers. Accordingly, we have investigated some of the properties of whey-soy drinks manufactured with lactase-treated sweet whey. The hedonic flavor scores of reconstituted samples of a whey-soy powder in which the whey was lactase-treated and of a powder made

from a lactase-treated mixture of whey and soy flour are shown in Table VI. Although no significant difference from the control was found in initial flavor scores, the lactase-treated products received significantly higher scores over the 6-month storage period. This reflected primarily the noticeably sweet taste conferred on the products by lactose hydrolysis. Soy flour also contains a carbohydrate which is hydrolyzed by lactase, but this did not result in any significant difference between the flavor scores of the two lactase-treated samples over the storage period.

TABLE VI.--Hedonic flavor scores of lactase-treated whey-soy beverage powders stored at room temperature.

Sample	Initial	Storage time (months)		
		1	3	6
Control (no treatment)	5.1	4.2	3.5	3.8
Lactase-treated whey	6.1	5.2[a]	4.6[a]	4.8[b]
Lactase-treated whey and soy flour	5.4	5.3[a]	4.6[a]	5.2[a]

[a]Significantly different from control at 1 percent level.
[b]Significantly different from control at 5 percent level.

Research carried out at the Eastern Regional Research Center has demonstrated that a variety of fermented products can be made from lactase-treated milk. Table VII lists these products and some characteristics of each. These include yoghurt, cottage cheese, and cheddar-type cheese (2, 8, 9).

TABLE VII.--Characteristics of fermented products made from lactase-treated milk.

Product	Comments
1. Yoghurt	Reduced set time; sweeter than control
2. Buttermilk	Sweeter than control
3. Cottage cheese	Reduced set time; increased yields
4. Cheddar type cheese	Reduced cheddaring time; reduced curing time

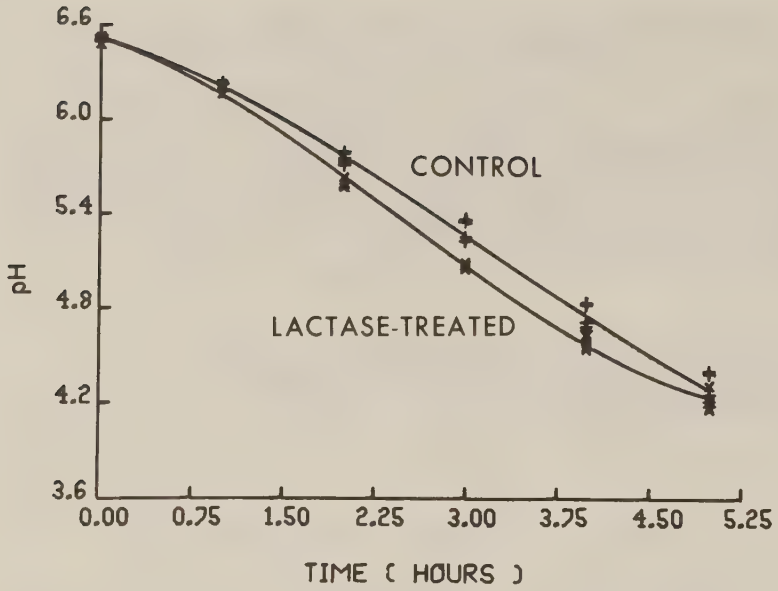


Figure 3.--pH change with time during yoghurt production.

The rapidly increasing popularity of yoghurt, especially the sweetened fruit-flavored variety which presently comprises 90 percent of the market (11), led us to believe that the sweetness of lactase-treated milk would produce a preferred yoghurt. The presence of glucose in the lactase-treated milk could also lead to more rapid acid formation by the organisms of the yoghurt cultures employed as well as to a more rapid set time. The curves traced in Figure 3 show that the pH decrease in the early stages of acid formation after inoculation is more rapid in lactase-treated skimmilk fortified with 4 percent untreated nonfat dry milk than in a similarly fortified control. After 5 hours' incubation, however, the pH of the two samples is the same. The lactase-treated yoghurt set in 3 hours compared to 4 for the control. Organoleptic evaluation by a consumer-type panel showed that tasters overwhelmingly preferred the lactose-hydrolyzed yoghurt because of the sweetening effect of lactase treatment.

As shown in Figure 4, when cottage cheese is made from skimmilk with 90 percent of its lactose hydrolyzed, acid development is also accelerated after addition of lactic starter culture. The time required to reach pH 4.6 during preparation of short-set cottage cheese was reduced by as much as 20 percent when lactase-treated milk was used. Lactose hydrolysis results in the formation of a firmer coagulum; this leads to less curd shatter and fines formation during cutting and milling of the curd. The increased yield obtained, as much as 10 percent in some cases, can represent a significant monetary advantage to the cottage cheese manufacturer.

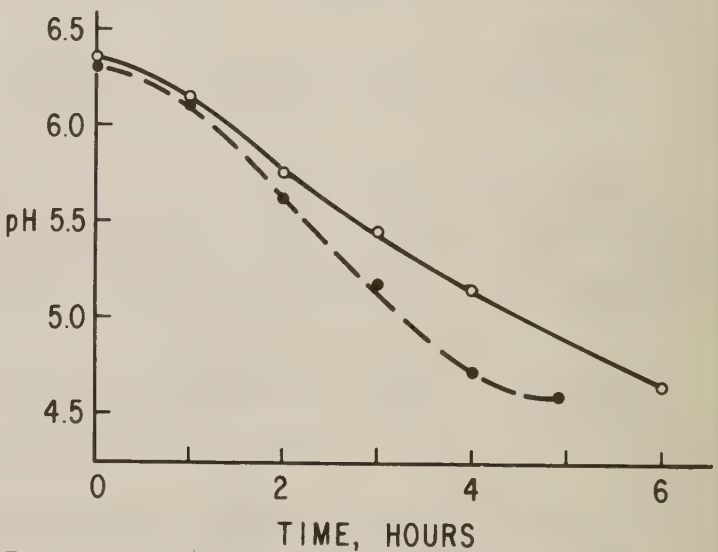


Figure 4.--pH change with time during cottage cheese manufacture. Solid curve is control, broken curve the sample made with lactase-treated skimmilk.

A new Cheddar-type cheese has been manufactured from lactase-treated whole milk using normal cheddaring techniques. This research is still in the exploratory phase, however, and we are not prepared to disclose our findings

at this time.

In closing, I believe we have successfully demonstrated that a variety of low-lactose milk products can be readily produced with properties at least equal to untreated controls. Because of the increased sweetness brought about by lactose hydrolysis, such products offer possibilities for use as ingredients in calorie-reduced sweet foods. Most importantly, low-lactose products can be utilized with confidence by a heretofore-unrecognized consumer population, lactose-intolerant individuals. However, the commercial feasibility of producing such products is strongly dependent upon cost. At the present time, commercial production of low-lactose products appears at best to be a break-even proposition economically based on use of the batch processes I have described here. I expect the situation will improve in the near future.

I would like to thank Drs. Guy, O'Leary, Pallansch, Thompson, Tamsma, and Ms. Gyuricsek for their data which formed the basis for much of this talk.

Lastly, I would like to thank the Enzyme Development Corporation of New York for the lactase made available to us, even though it must be stated that the results presented or statements made in this paper can in no way be construed as an endorsement of their product by the U.S. Department of Agriculture over others not mentioned.

LITERATURE CITED

(1) Kosikowski, F. V., and L. E. Wierzbicki. 1973. Lactose hydrolysis of raw and pasteurized milk by *Saccharomyces lactis* lactase. J. Dairy Sci. 56:146.

(2) O'Leary, V. S. 1974. Unpublished data.

(3) Paige, D. M. 1973. Unpublished data.

(4) Paige, D. M., T. M. Bayless, G. D. Ferry and G. G. Graham. 1971. Lactose malabsorption and milk rejection in Negro children. Johns Hopkins Med. J. 129: pp 163-169.

(5) Pallansch, M. J. 1972. New methods for drying acid whey. Proceedings, Whey Products Conference, Chicago, Ill., June 14-15. ERRL Publ. 3779, U.S. Dept. Agric., p 100.

(6) Peryam, D. R., and F. J. Pilgrim. 1957. Hedonic Scale method for measuring food preference. Food Technol. 11(9): Insert 9-14.

(7) Protein Advisory Group of the United Nations System. 1972. Report on the PAG ad hoc working group meeting on milk intolerance - nutritional implications. Washington, D.C., October 29-30, 1971. Milk Intolerance Nutritional Implications Document 1.27/9. p 18.

(8) Thompson, M. P. and D. P. Brower. 1974. Manufacture of Cheddar cheese from hydrolyzed lactose milks. J. Dairy Sci. 57:598.

(9) Thompson, M. P., and D. M. Gyuricsek. 1974. Manufacture of yogurt, buttermilk, and cottage cheese from hydrolyzed lactose milks. J. Dairy Sci. 57:584.

(10) Tumerman, L., H. Fram, and K. W. Cornely. 1954. The effect of lactose crystallization on protein stability in frozen concentrated milk. J. Dairy Sci. 37:830.

(11) United Dairy Industry Association. 1974. The Household Yoghurt Market, April 1972 - March 1973. Rosemont, Illinois 60018.

WHEY PRODUCTION AND UTILIZATION IN EUROPE; APPLICATIONS OF LACTASE-TREATED WHEY AND OTHER DAIRY PRODUCTS

F. A. M. BOUVY

Gist-Brocades nv
Delft, Netherlands

INTRODUCTION

The idea of enzymatic hydrolysis of lactose as an extension of whey utilization is far from new. It was not only referred to several times in earlier whey conferences, but elsewhere as well. Several advantages are claimed as a result of the hydrolysis of lactose into glucose and galactose, but few investigations showing the practical utility of these claims have been made. One main reason that more work on the application of lactose hydrolysis has not been done may be that commercially feasible lactase preparations have not been available.

On the other hand, development of such lactase preparations is strongly dependent on the existence of well developed applications. A breakthrough in this mutual inhibition between the development of practical applications and the availability of useful lactase preparations is needed. The approach based on the use of immobilized lactase is very promising for the future, but in my opinion not yet completely feasible to meet the present need for an industrial process for the treatment of milk or whey. The real problem that has to be solved today is the exploration of additional whey outlets. I strongly believe that commercially available lactase preparations such as Maxilact, which Miss Holsinger mentioned in her paper and which is already being carefully investigated for different applications, will give a powerful push in the right direction. Without the cooperation of the dairy industry, however, it is impossible to investigate all the proposed applications in sufficient detail to determine their practical benefits.

It is therefore my intention, after a short summary of whey production and utilization in Europe, to discuss lactose hydrolysis with you briefly and to present schematically the anticipated applications of lactase-treated whey and other dairy products.

EUROPEAN WHEY PRODUCTION AND UTILIZATION

It is rather difficult to collect relevant data from all European countries since production statistics on whey are not available. Even statistics on the utilization of whey are difficult to collect for some countries. Whey production is in fact derived with the help of a conversion factor using the available production statistics for cheese. While the production of soft and hard cheeses is well known for most countries, production data on fresh cheeses are more difficult to collect and less reliable.

For all these reasons I have restricted myself to the data available in the 9 countries of the enlarged Common Market, where, without doubt, the largest whey producers of Western Europe are. Even for this group of countries, however, I don't pretend to have complete data. For instance, the whey derived from the production of caseinates in all countries is left out, and only for France and the Netherlands is lactose production included in the figures for whey utilization. For the whey production derived from soft and hard cheeses I have used a conversion factor of 8.5 and for the whey production derived from fresh cheeses, being of the European quark-type only, I have used a factor of 2. For the conversion of fluid whey into dry whey I have used a factor of 1/15. All the processed whey for food and feed, whey concentrate, powder, lactose and other utilizations is compiled into one figure. Only the whey used for direct fluid feed is indicated separately.

Table I shows whey production and utilization within the enlarged Common Market in 1972. The data suggest that only in the Netherlands is enough of the whey utilized to prevent a pollution problem. The Netherlands excepted, there thus exists in Western Europe a real need for improved and enlarged whey utilization. But where there are a large number of small cheese producers, for example in France, it will not be easy to utilize additional whey.

PROPERTIES OF *SACCHAROMYCES LACTIS* LACTASE

Substrate specificity. Lactase or β-D-galactosidase, more precisely defined as β-D-galactoside-galactohydrolase with enzyme number 3.2.1.23, is not only active on its natural substrate lactose or milk sugar, but on other substrates as well which contain a β-D-galactosidic bond. The reaction in which ortho-Nitrophenyl-β-D-galactoside is hydrolyzed into galactose and the yellow-colored ortho-Nitrophenol is used in the standard assay method for lactase. (See Figure 1.)

Lactase catalyzes transfer reactions at the same time; instead of water, another sugar molecule becomes the acceptor of the β-D-galactose moiety. This transfer principle is responsible for the minor amounts of oligosaccharides which are present during and after lactose hydrolysis. The higher the starting lactose concentration, the more oligosaccharides are found. Due to the fact that during hydrolysis a small amount of galactose is always transferred to another sugar molecule, slightly more free glucose than galactose is present afterwards.

TABLE I.--Whey production and utilization in the Common Market, 1972
x 10^3 tons

Country	Cheese production			Total whey production (dry basis)	Whey utilization (dry basis)			Utilization as % of production
	Soft and hard	Fresh	Total		Processed	Fluid feed	Total	
France	630	185	815	380	240	70	310	81%
Italy	440	80	520	260	?	?	?	?
Netherlands	315	1	316	180	170	8	178	99%
W. Germany	250	300	550	180	≥60	70	≥130	≥72%
United Kingdom	180	?	180	100	≥14	35	≥ 50	≥50%
Denmark	130	0.2	130	74	?	?	?	?
Ireland	45	?	45	26	?	?	?	?
Belg./Lux.	25	20	45	17	≥ 8	?	≥ 8	≥47%
Total Common Market	2,015	586	2,601	1,217				

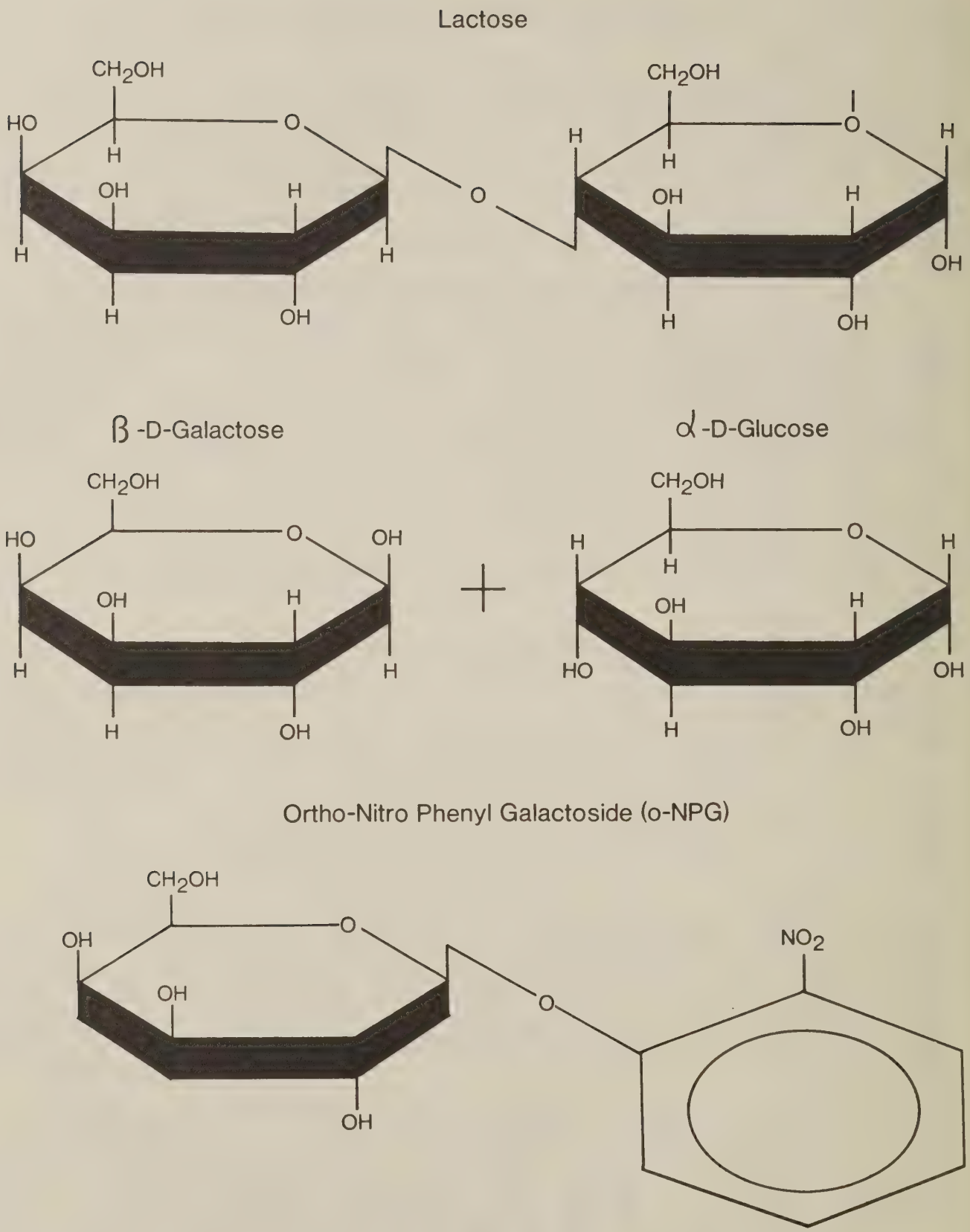


Figure 1.--Lactase substrates, lactose (top) and ortho-nitro phenyl galactoside (o-NPG, bottom). Lactase hydrolyzes lactose into glucose and galactose (middle), and also hydrolyzes o-NPG by splitting its galactosidic bond to produce galactose and ortho-nitro phenol.

pH Activity profile. This profile (Figure 2) is measured by the standard assay method at different pH's. The pH optimum of the enzyme almost coincides with the normal pH range found in milk. Below pH 5 lactase activity is completely lost. This is irreversible.

pH Stability profile. This profile (Figure 3) is measured by the standard assay method at pH 7.0 after incubation of the enzyme for 30 minutes at 30°C at different pH's with no substrate present.

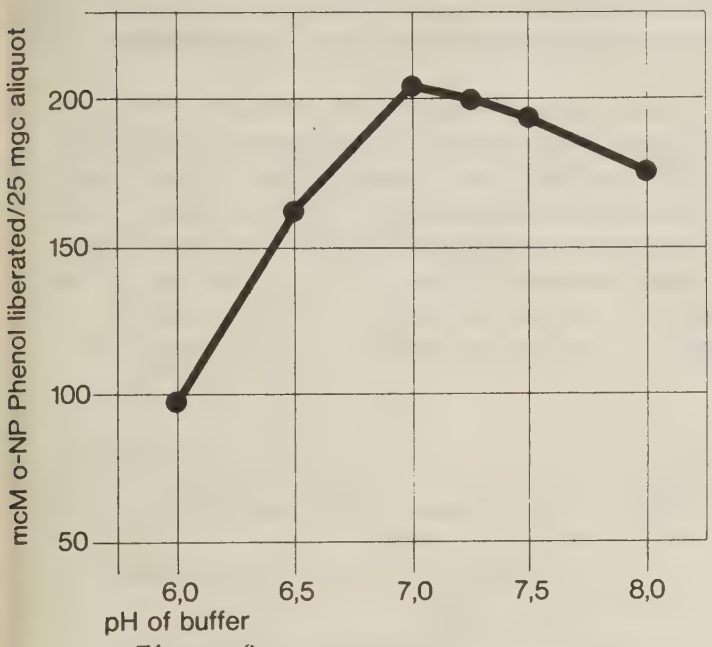


Figure 2.--Effect of pH on enzymatic activity.

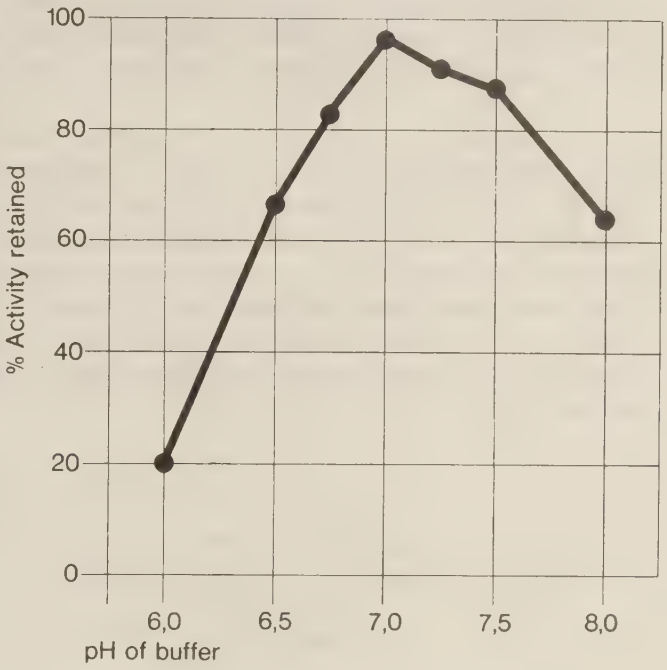


Figure 3.--Effect of pH on the stability of the enzyme (potassium phosphate buffer).

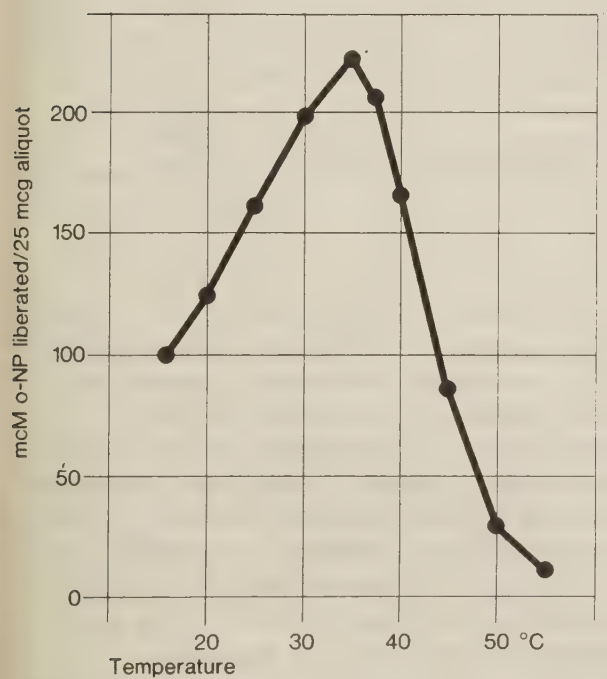


Figure 4.--Effect of temperature on enzymatic activity.

Temperature-activity profile. Here the standard assay method is used at different temperatures (Figure 4). A temperature of 35°C is optimum for an incubation for 10 minutes with ONPG as substrate. The heat stability of the enzyme is rather moderate; the advantage of this is that normal pasteurization completely inactivates the enzyme in milk or whey.

Activators and inhibitors. The enzyme is more active on lactose in the presence of potassium than of sodium. Thus when pH adjustment of whey is necessary the use of sodium hydroxide has to be avoided. Heavy metals cause a very strong inhibition of the enzyme. Low concentrations of manganese are essential in the maintenance of the active structure of the enzyme. Magnesia and

cobalt partly replace manganese in this function.

Because galactose is a competitive inhibitor of the enzyme, and because the transgalactosidase activity is more pronounced at higher lactose concentrations, it is recommended that the lactose be hydrolyzed as dilute as possible and that the enzyme be inactivated before the milk or whey is concentrated.

Lactose hydrolysis in milk and whey. The milk or whey to be treated should be of good microbiological quality; otherwise lactase activity is inhibited to some extent. Normal pasteurization procedures are recommended.

In whey high levels of starter organisms depress lactase activity, so that pasteurization is a must. Another important measure for optimum hydrolysis of whey is adjustment of the pH to at least 6.5 with potassium or ammonium hydroxide. The optimum temperature for hydrolysis of either milk or whey is between 30 and 35°C. Lactases derived from *Saccharomyces lactis* such as Maxilact are also very effective at temperatures between 4 and 10°C. Figures 5 and 6 show the relationship between the level of enzyme activity, the incubation time and the resulting degree of hydrolysis in milk and whey at 32°C and 30°C respectively.

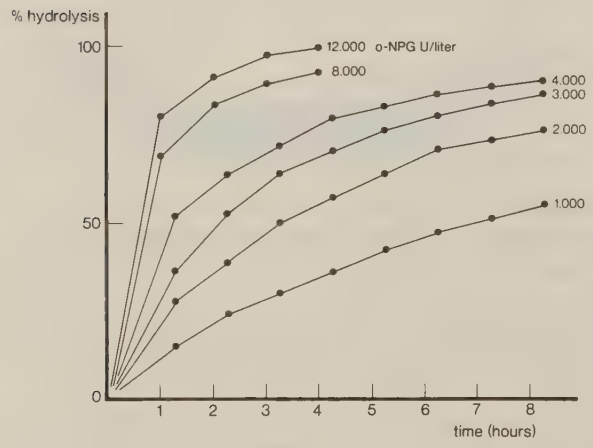


Figure 5.--Lactose hydrolysis in milk at 32°C. (initial lactose concentration: 4.5 percent).

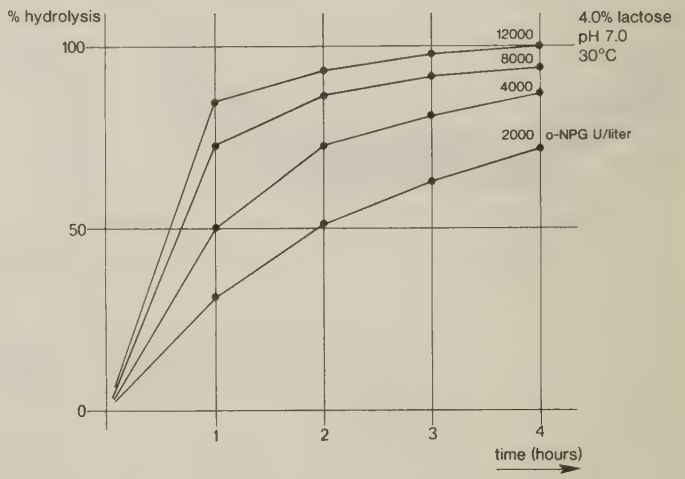


Figure 6.--Lactose hydrolysis in sweet whey.

Determination of the degree of hydrolysis. Analysis of dairy products in which the lactose is hydrolyzed requires special attention because glucose and galactose interfere with the usual lactose assay methods. The method of Tauber-Kleiner, based on the reduction of copper ions, is an example of a useful routine assay method. A more sophisticated method is the specific enzymatic sugar assay for glucose, galactose, and lactose. This method, which requires expensive equipment, is not very well suited for routine analysis. The method which gives the most information is the gas chromatographic assay where all the sugars, including the oligosaccharides, are detected at the same time. Unfortunately, to make this method completely reliable, a rather

laborious volatilization procedure is necessary; thin-layer chromatography is a more practical alternative, although it does not give completely quantitative results.

LACTASE APPLICATIONS

In order to establish the principles on which all lactase applications are based, here is a list of the basic physical and chemical effects of lactose hydrolysis, followed by a more detailed look into each effect and its possible applications:

Reduced lactose content

Prevention of lactose crystallization

Increased solubility

Higher osmotic pressure

Lower viscosity

Increased sweetness

More universally fermentable sugars

Increased level of reducing sugars

Lower molecular weight

Reduction of lactose content. To help the few milk-intolerant individuals in Holland, one of our dairy companies has for several years been producing milk powders in which over 99 percent of the lactose is hydrolyzed by Maxilact-treatment. Under the trade name "Lactalac" it is used in hospitals and sold by druggists and health-food stores only as a dietary specialty.

In Italy a sterilized fluid milk with 80 percent of the lactose hydrolyzed is available in limited quantity. The product, named "Zymil," is sold by pharmacies only.

Similar fluid or powdered products are under development in several countries. It seems that also for baby foods a partial hydrolysis of the lactose in milk will have advantages.

Since the degree of hydrolysis has to be well over 50 percent in these cases a point of special attention is the increased level of reducing sugars. If such hydrolyzed milk is not quickly consumed, stored under refrigeration, or concentrated, spray dried, and packaged with special care, nonenzymatic browning (Maillard reaction) will give the product an unattractive color and off-flavor.

The production of lactose-free cultured milk products is in fact quite easy. Yoghurt cultures in Europe have a certain preference for lactose instead of glucose. Consequently, only 80 percent hydrolysis of the milk before culturing is sufficient for the production of yoghurt in which after culturing 95 percent of the lactose is hydrolyzed.

In general, hydrolysis of the lactose in milk or whey makes milk sugar no longer the limiting factor for incorporation of milk or whey in special diets, baby foods, breakfast drinks or cereals.

Finally, some animal species cannot tolerate high levels of lactose. Poultry is a good example. Although incorporation of whey powders in poultry feed seems to improve the meat quality, in practice the lactose content of whey powder is too limiting to give the full benefit of its use. It is claimed that a product like "wheast," whey in which lactose is converted into yeast, overcomes this disadvantage. In a similar manner hydrolyzed whey can find increased use in poultry feed, for instance, in the form of a concentrated whey-syrup, which can replace the use of molasses.

Prevention of lactose crystallization. The prevention of lactose crystallization in condensed or evaporated milk, in frozen milk concentrates, or in concentrated whey syrups is quite economical because only 20 to 30 percent of the lactose has to be hydrolyzed for complete absence of crystallization, even after prolonged storage. It is not necessary to hydrolyze the oversaturated part of the lactose completely because small amounts of glucose and galactose inhibit the formation of lactose crystals sufficiently.

According to this principle sandiness in ice creams and frozen desserts can be avoided without the need of stabilizers. In candies and confections a softer texture seems to be the result when partially hydrolyzed milk or whey is used instead of untreated dairy products.

An adverse effect of lactose hydrolysis is that it hampers spray drying. This is not a problem with milk, where even after 99 percent hydrolysis of the lactose, spray drying can be done under stringent conditions quite easily because the casein complex seems to act as a carrier. In whey, however, the glucose and galactose from hydrolysis cause problems in spray drying. Even so, hydrolyzed whey has been successfully foam-dried in pilot-plant equipment. In England a mixture of skim milk and hydrolyzed whey is currently spray dried in standard equipment. Not only casein, added as milk, but also soy protein seem to be effective carriers for the spray drying of hydrolyzed whey when equipment specially adapted to dry whey alone is not available.

Increased solubility. Glucose and galactose are more soluble than lactose. Their solubility at 25°C in percent by weight is as follows:

Lactose	22
Glucose	74
Galactose	68

Together with the increased osmotic pressure, giving protection against growth of microorganisms, the improved solubility of sucrose enables the production of highly concentrated, yet fluid and easy-to-handle, hydrolyzed whey concentrates. Syrups with a total solids content of 70 to 80 percent are still quite fluid and have a good shelf life; nonenzymatic browning is satisfactorily prevented for months in refrigerated storage.

For the production of such whey syrups only a vacuum evaporator is needed, a low investment compared with the acquisition of spray-drying equipment. Removing the proteins and/or salts by fractionation makes such whey syrups even more attractive for incorporation in a diversity of foods and drinks.

Increased sweetness. The sweetness of the several sugars relative to sucrose (100) in neutral water at a concentration of 10 percent by weight is as follows:

Lactose	40
Glucose	75
Galactose	70

In unconcentrated milk or whey the sweetness becomes obvious when 40 to 50 percent or more of the lactose is hydrolyzed. In fluid skim milk 40 percent hydrolysis of the lactose gives the milk more body and mouth feel without a distinctly sweeter taste. In Holland a taste panel estimated that yoghurt, produced from milk in which 80 percent of the lactose was hydrolyzed, had an additional sweetness comparable to the addition of about 7 grams of sucrose per liter. The theoretical value, based on the sugars analyzed in the blank and experimental yoghurt, should be 7.3 grams per liter. In yoghurt the additional sweetness after lactose hydrolysis is not overwhelming because part of the glucose is used by the culture and because normal yoghurt already contains the galactose liberated from the lactose used by the cultures.

However, an increased content of total solids before hydrolysis or an addition of hydrolyzed whey will improve the body and sweetness in yoghurt. Concentrated whey syrups in which 70 to 90 percent of the lactose is hydrolyzed contain about 50 percent glucose plus galactose. These syrups are extremely sweet and it is already anticipated that they will be incorporated into ice creams, frozen desserts, bakery products, candies and confections, bread spreads and soft drinks. In all these cases the additional sweetness due to lactose hydrolysis in the dairy product is realized without the addition of calories. In products where the additional sweetness from lactose hydrolysis is sufficient, violation of the natural status of the product by noncaloric sweeteners can be avoided.

More universally fermentable sugars. Generally speaking, more organisms can use glucose or galactose as a carbon source than lactose. If they can use lactose at all they often prefer glucose or galactose. An interesting example is bakery yeast. Whey powder is used in baking because lactose is not fermentable, and is therefore after proofing still present to help the browning of the crust. If this lactose is hydrolyzed the yeast ferments the glucose,

but under practical conditions of proofing galactose is not fermentable. For browning galactose is at least as reactive as lactose. Besides this we have found that whenever whey powder has an adverse effect on the volume and CO_2 development during proofing, hydrolysis of the lactose eliminates these adverse effects completely.

Another interesting example in this class is cheese production. As reported in Miss Holsinger's paper, partial hydrolysis of the milk lactose before culturing cottage cheese causes faster acid production and a firmer curd, resulting in a reduced set time and a higher yield. For Cheddar, preliminary data indicate that the ripening time is shortened when lactose-hydrolyzed milk is used. The exact mechanism in both cases is not yet understood, but it is most likely that the availability of glucose and galactose instead of lactose alone is the primary cause. The production of other fresh, soft, and hard cheeses from hydrolyzed milk is not yet investigated sufficiently to estimate the real impact of this application.

The resulting whey from such cheese production is automatically hydrolyzed. While the use of lactase can be economical due to the shorter production time and increased yield or due to the shorter ripening time of the cheese, this hydrolyzed whey is lactase-treated by the cheapest possible way. When such hydrolyzed whey fractions become widely available their use as raw material for industrial fermentations can be anticipated as well.

Increased level of reducing sugars. Although for some applications non-enzymatic browning is avoided as much as possible, for others it is a highly wanted property. In baking, for instance, galactose is in practice not fermentable and thus still present after proofing to give an optimal color to the crust. The effects of hydrolyzed milk and whey in caramel-type candies and confections are under investigation in England and look very promising but firm results are not yet available.

Lower molecular weight. Molecules of glucose and galactose, with a molecular weight of 180 each, are only about half the size of lactose molecules, which have a molecular weight of 342. To my knowledge, there has not yet been any investigation on whether lactose hydrolysis affects the sugar retention of whey during ultrafiltration. Since there is still substantial lactose retention during ultrafiltration for whey protein concentrates, any decrease in this retention as a result of lactose hydrolysis would be an advantage not only for the production of a purer whey protein concentrate but also for an improved utilization of the permeate fraction. If hydrolysis before ultrafiltration is senseless there is still the possibility of hydrolyzing the lactose in the permeate in order to produce a kind of concentrated sugar syrup. After demineralization such a syrup would be very bland in flavor. We have found that because highly concentrated hydrolyzed whey permeates are still fluid, part of the minerals can be removed by simple precipitation and centrifugation.

ECONOMICS OF LACTOSE HYDROLYSIS

It is obvious that economics play an important role in the application of lactase treatment of dairy products. I can only give you data based on the experience we have had with our own preparation Maxilact. For 50 percent hydrolysis in milk, an enzyme cost of approximately 0.75 to 1.5 cents per quart is anticipated. For whey hydrolysis, where flavor characteristics are not as important as for fluid milks, a less purified lactase preparation can be used to accomplish 50 percent hydrolysis at a cost between 0.2 and 0.4 cent per quart.

CONCLUSION

I sincerely hope I have shown you clearly how worthwhile it is to investigate fully the beneficial influence a certain degree of lactose hydrolysis can have on the processing or utilization of milk and whey in a variety of foods and drinks. The applications I have described are certainly only a fraction of the possible uses for lactose-hydrolyzed dairy products. With all the experience you have in dairy products processing, you certainly can improve upon the concepts to the point where they will become the basis for profitable and successful operations. We are always prepared to discuss openly and frankly the economics of the new processes and products we have presented.

POTENTIAL FOR HYDROLYZED LACTOSE

T. A. NICKERSON

University of California
Davis, CA 95616

When pondering the potentials of hydrolyzed lactose, we find divergent views. They range from the negative pessimistic view that there's no need for it to the positive Utopian view that it will solve all our whey disposal problems. If we approach the problem from the negative side, we can say that the two major changes that lactose hydrolysis accomplishes are a) reducing crystallization or sandiness in milk products, and b) increasing sweetness. Furthering this view it could be emphasized that sandiness is not a serious problem to the dairy industry and it too can be controlled by methods other than hydrolysis, and as for sweetness we have cheaper and sweeter sources than hydrolyzed lactose. If we accept such a view, my talk would be over and we should go on to something with more potential. Obviously we won't accept this, but such a view does emphasize that the world is not likely to beat a path to our door to get hydrolyzed lactose--at least not until we adequately demonstrate its values.

How will hydrolysis be accomplished? This conference includes several discussions on the use of lactase enzymes to hydrolyze lactose. Since lactases from various sources are different enzymes having different pH optimums and having maximum activity at different temperatures, it seems that lactases will be available for hydrolysis in different products under varying processing conditions. Acid hydrolysis, which has not been discussed at the conference, offers an alternative process for aqueous lactose solutions and for certain whey products. This method appears feasible without excessive destruction of sugar or whey protein if conducted near 60^{o}C. (3).

Having accepted that hydrolysis in a variety of milk products is possible, what changes are likely to be incurred? There are at least five: 1) increase in sweetness, which may be an economy with today's high sugar prices; 2) decrease in lactose content, which is important when we consider lactose intolerance in animals as well as in man; 3) change in crystallization pattern, which may result in products with less sandiness or defective texture, or may promote softer confections with delicate texture; 4) lowering of the freezing point, which might be important in ice cream and in frozen milk; 5) changes in viscosity and humectant properties resulting from hydrolysis.

Sweetness in general is currently creating considerable scientific interest both as it related to physiological function and to chemical structure.

Sweetness of various sugars is generally compared in relation to the sweetness of sucrose (Figure 1). Relative sweetness of various sugars is not a constant relationship, but is dependent upon many factors. For example, temperature of presentation of a sugar solution alters its apparent sweetness; the same solution tastes much sweeter cold than it does hot. Chemical configuration plays a role; thus β-lactose is appreciably sweeter than α-lactose. Surprisingly the opposite is true for the hydrolysis products of lactose. For both glucose and galactose, the α-configuration is sweeter than the β-form. Since sweetness is related to molecular structure, the order of relative sweetness for a group of sugars will depend upon whether they are compared in terms of molar concentration or as percent by weight. From a practical standpoint another very important factor is concentration. Two sugars may be very different in relative sweetness if compared as dilute solutions, but may be quite similar in sweetness when concentrated solutions are compared. Table I shows that the relative sweetness of lactose increases in more concentrated solutions.

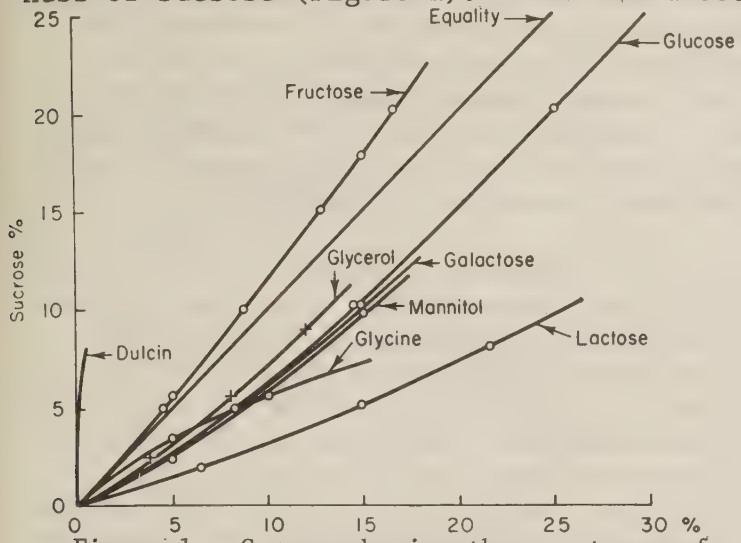


Figure 1.--Curves showing the sweetness of various compounds compared with sucrose (from Reference 1).

TABLE I.--Effect of Concentration on relative sweetness of sugars. (Percent concentration to give equivalent sweetness).

Sucrose	Glucose	Fructose	Lactose	Reference
0.5	0.9	0.4	1.9	5
1.0	1.8	0.8	3.5	5
2.0	3.6	1.7	6.5	5
2.0	3.8	-	6.5	2
2.0	3.2	-	6.0	4
5.0	8.3	4.2	15.7	5
5.0	8.3	4.6	14.9	2
5.0	7.2	4.5	13.1	4
10.0	13.9	8.6	25.9	5
10.0	14.6	-	0	2
10.0	12.7	8.7	20.7	4
15.0	17.2	12.8	27.8	4
15.0	20.0	13.0	34.6	5
20.0	21.8	16.7	33.3	4

Relative sweetness values are normally determined in model solutions rather than in formulated food systems. This is unfortunate since it is recognized that other food components such as salts, acids, or flavorings also affect perceived sweetness. Also a mixture of sugars can have a different sweetness impression than the individual sugars alone. Several workers have observed a synergistic sweetness effect resulting from the combination. This suggests that a partial hydrolysis of lactose so that the three sugars--lactose, glucose, and galactose--are present may have advantages in sweetness.

Because of the interaction of food constituents on relative sweetness and all these other variables, it is difficult to give specific rules for the use of different sugars and each food product must be considered individually. Thus the usefulness of hydrolyzed lactose as a sweetening agent remains to be determined. Although Figure 1 indicates the hydrolysis products may be 3 to 4 times as sweet as lactose, we need to know how much sucrose could be replaced if hydrolyzed whey or hydrolyzed lactose were used. In Virginia Holsinger's paper presented earlier in this conference we learned that a 10 percent saving in sugar could be made by using hydrolyzed lactose in ice cream. We need more data of this type to convince food processors that they should consider such substitutions in their products.

Also would acceptability of confections be improved by this mixture of sugars rather than by use of sucrose alone? This question involves not only relative sweetness, but the potential use of the hydrolysis products to change the crystallization habit of lactose, sucrose, or other commercial sugars. Solubility of a sugar is generally decreased by the presence of other sugars in solution. This effectively increases the level of supersaturation in the food product and the degree of supersaturation alone can have a significant effect upon crystal habit and the numbers and size of crystals. The other sugars can also interfere with crystallization and change growth patterns.

The most complete study of the solubility of lactose and its hydrolytic products is that of Talley and Hunter (7). The relationships of these three sugars is summarized in Figure 2. It shows that the solubility of each is decreased by the presence of the other sugars in the solution (g. anhydrous sugar per 100 g. solution).

The following equations representing the solubility relationships of lactose (La), D-glucose (Gl), and D-galactose (Ga) in water at 25°C were calculated from the experimental data given by Talley and Hunter (7):

$$La = 17.50 - 0.2452Gl - 0.2477Ga$$

$$Gl = 50.38 - 0.6305La - 0.5550Ga$$

$$Ga = 32.09 - 0.3898Gl - 0.3973La$$

Using the lactose equation we see its solubility decreases as glucose and galactose are added to the solution. Since these are released equally by hydrolysis, the equation shows that lactose solubility is reduced to zero by the presence of 35.5 g. hydrolysis products/100 g. solution (or whenever 71.0 g. or more of lactose is hydrolyzed). Using the equation for galactose, we find that whenever more than 23 g. of lactose is hydrolyzed per 100 g. solution the syrup becomes saturated with respect to galactose. This is close to the 21 g. reported by Ramsdell and Webb (6). The calculated value for saturation with glucose is when 32.4 g. of lactose has been hydrolyzed per 100 g. solution. However, the fact that syrups become saturated with respect to the three sugars at relatively low total solids levels does not imply that crystallization problems will be encountered in more concentrated syrups. Often mixtures are more stable than pure solutions; one interfering with nuclei development of another. Ramsdell and Webb (6), for example, observed galactose crystallization only occasionally during storage of hydrolyzed lactose syrups containing 58 percent solids. Most samples remained free of crystal formation even after months of storage. These authors attributed the stability to hydrolytic byproducts retarding crystal growth. Whenever syrups were concentrated to 70 percent or more solids, however, crystals developed during only a few weeks storage.

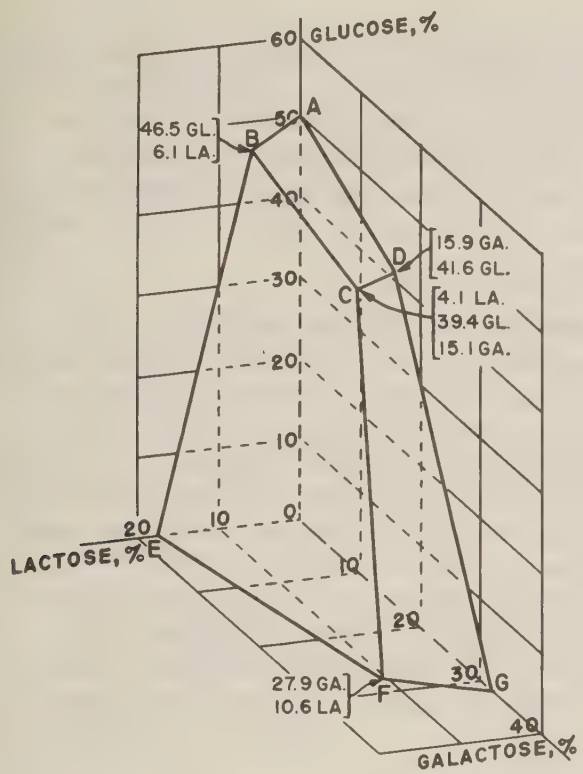


Figure 2.--Solubility relationships of lactose, D-glucose, and D-galactose in water at 25° (from Reference 7).

Again we do not have adequate data to enable predictions for the future use of hydrolyzed lactose, but concentrated syrups are certainly within the realm of possibility. We need to know if hydrolytic byproducts--including the oligosaccharides, the enzymatic byproducts of lactase hydrolysis--can be used to inhibit crystallization. Also we must be assured of the flavor and color stability of the syrups produced by both acid and enzyme hydrolysis. Properties of syrups in which only part of the lactose is hydrolyzed apparently have not been studied, and this needs to be done.

Other properties of sugar syrups that are of interest to food processors are viscosity and humectant qualities. Viscosity is not only important for ease of handling and product loss, but it can also contribute to desirable physical properties of the preparation and can contribute to crystallization control. Many foods on standing lose moisture and become dry and stale. One of the features of some types of sugar syrups is their ability to retain moisture and retard drying out of the food. We don't know how hydrolyzed lactose

will meet these needs, but based on composition and properties of the sugars we have no reason to doubt that it will be as satisfactory as some presently successful commercial syrups.

In addition to production of syrups, utilization of the hydrolysis reaction on lactose offers some other interesting possibilities. Feeds, for example, currently are the most important outlet for whey solids. However, lactose intolerance of a number of animals limits how much whey can be included in their feed. Hydrolysis by either acid or enzyme should greatly increase the potential of this outlet by not only reducing the lactose, but by increasing palatability of the product as well.

In ice cream it seems to me that the potential will depend upon the quality and properties of the syrup. If economies are possible by using a hydrolyzed syrup or hydrolyzed whey, and if the body and texture of the product is improved, both of which seem reasonable, then increased use of whey solids or lactose in frozen dairy products would be assured. Economics of the formulations will be the key, with improvements in body and texture an added bonus. The possibility of reducing the incidence of sandiness is not a good selling point in my view, since the ice cream industry currently is not troubled by sandiness. If this were a problem the industry would not be substituting whey solids for solid-not-fat in many of their products as is the current practice. The limiting factor controlling the extent of substitution is generally saltiness or flavor quality of the product. Hydrolyzed syrups should be an improvement.

In the area of candies and confections, hydrolyzed whey and syrups should be useful to improve the texture or creaminess by controlling sugar crystallization, probably with a decrease in sweetness.

There has been interest for many years in distributing frozen concentrated milk similar to frozen orange juice. However, until now storage stability has not been satisfactory. Lactose crystallization could not be avoided in the concentrated product during prolonged storage. Associated with lactose crystallization was destabilization of the caseinate system so that when the product was reconstituted the protein settled out (9). Hydrolysis of a portion of the lactose by lactase effectively retards crystallization and greatly prolongs storage stability (8). Now through the use of lactase, frozen milk concentrate would appear to be a sure thing. Incidentally, it should make an ideal product to test out the role of lactose intolerance in nonmilk drinkers. I was pleased to hear in Virginia Holsinger's paper that one study has been made in this direction.

In conclusion I want to emphasize that I do believe there is a future for hydrolyzed lactose, but it is only a potential. It is up to the whey industry to develop that potential through new products and vigorous promotion.

LITERATURE CITED

(1) Amerine, M. A., Pangborn, R. M., and Roessler, E. B.

1965. Principles of sensory evaluation of food. Academic Press, New York and London.

(2) Cameron, A. T.

1947. The taste sense and the relative sweetness of sugars and other sweet substances. Sugar Research Foundation Rept. No. 9, New York.

(3) Coughlin, J. R., and Nickerson, T. A.

1974. Acid-catalyzed hydrolysis of lactose in whey and aqueous solutions. J. Dairy Sci. 57: 583 (Abst.).

(4) Dahlberg, A. C., and Penczek, E. S.

1941. The relative sweetness of sugars as affected by concentration. N.Y. State Agr. Expt. Sta. Tech. Bull. 258.

(5) Pangborn, R. M.

1963. Relative taste intensities of selected sugars and organic acids. J. Food Sci. 28: 726.

(6) Ramsdell, G. A., and Webb, B. H.

1945. The acid hydrolysis of lactose and the preparation of hydrolyzed lactose sirup. J. Dairy Sci. 28: 677.

(7) Talley, E. A., and Hunter, A. S.

1952. Solubility of lactose and its hydrolytic products. J. Am. Chem. Soc. 74: 2789.

(8) Tumerman, L., Fram, H., and Cornely, K. W.

1954. The effect of lactose crystallization on protein stability in frozen concentrated milk. J. Dairy Sci. 37: 830.

(9) Winder, W. C.

1962. Physical-chemical stability of frozen whole and concentrated milks. J. Dairy Sci. 45: 1024.

IMMOBILIZED LACTASE SYSTEMS

W. H. PITCHER

Corning Glass Works
Corning, NY 14830

The hydrolysis of the lactose in whey to glucose and galactose is becoming an attractive commercial process. As the cost of sweeteners from cane and corn continues its dramatic climb (having almost doubled within the past year), certain segments of the food industry are looking for alternative sources of their sugar supply. The use of the glucose isomerase process, where glucose is converted to its much sweeter isomer, fructose, is an example of the food industry's efforts to "stretch" the supply of sweetening sugars.

Acid whey (the solids being about 75 percent lactose), a byproduct of cottage cheese manufacture, is of low value and can present a waste disposal problem to cheese producers. On the other hand, the dairy industry has been particularly hard hit by the cost increases of sweeteners which must be purchased in large quantities for use in ice cream, yogurt, egg nog and other dairy products. Relief from this price squeeze may be available within the dairy industry itself. Converting the lactose present in whey to glucose and galactose increases the sweetness and solubility of whey solids, thus allowing potential use of whey and modified whey as a sweetener substitute in many dairy products.

The conversion of lactose to glucose and galactose is promoted by the enzyme lactase. At the current high prices of lactase, immobilized enzymes provide the most promise of making this conversion economically feasible. Attaching enzymes to insoluble carriers makes possible their repeated or continuous use over extended periods of time.

The purpose of the studies discussed here was to investigate the feasibility of using immobilized lactase for the commercial hydrolysis of the lactose in cheese whey.

BACKGROUND

Previous studies by Weetall et al (9,10), Olson and Stanley (5), Stanley and Palter (8), Charles et al (2), and Pitcher (7) have demonstrated the general feasibility of lactase immobilization and the use of a lactase system for hydrolysis.

Crude cost estimates (2,7) have also been made. However, sufficient data, including long-term stability, reactor sanitization, and additional processing costs, have not been presented.

Weetall et al (9) have discussed the kinetics of lactose hydrolysis giving the rate equation as

$$v = \frac{kES}{S + K_M \left[1 + (P/K_i)\right]} \qquad (1)$$

where v = reaction rate, k = turnover number, E = amount of enzyme, $kE = V_{max}$ (the maximum rate achieved when $S >> K_m$), S = substrate (lactose) concentration, K_m = Michaelis constant, P = product concentration, and K_i = inhibition constant.

The integrated form of equation (1) for a batch or plug flow reactor, assuming no product present initially, is

$$\frac{Et}{V} \text{ or } \frac{E}{F} = \frac{1}{k} \left\{ \frac{K_i - K_m}{K_i} (S_o - S) + \left(\frac{K_m S_o}{K_i} + K_m\right) \ln (S_o/S) \right\} \qquad (2)$$

where V = volume of substrate solution, t = elapsed time, S_o = initial or feed substrate concentration, S = substrate concentration at time t or in the reactor effluent, and F = volumetric flow rate of substrate.

Weetall et al (10) report experimental values of 0.05 M and 0.0039 M respectively for K_m and K_i for soluble Wallerstein lactase.

METHODS AND MATERIALS

The lactase enzyme was immobilized on porous silica and titania bodies by the aqueous silane-glutaraldehyde method (11). The porous silica bodies, of 30/45 mesh size having a 370 Å average pore diameter, were made by D. L. Eaton, Corning Glass Works, using a procedure developed by R. A. Messing, also of Corning Glass Works. Titania porous bodies were similarly prepared. The enzyme used was the Wallerstein Company's Lactase-LP, a β-galactosidase from *Aspergillus niger*. An enzyme assay similar to that reported by Weetall et al (9) was utilized where one unit was defined as the amount of enzyme necessary to convert one μ mole/min. of lactose to glucose and galactose in a 16 percent (w/w) lactose solution. The only difference was that in this study immobilized enzyme (IME) assays were typically carried out at 40°C. and pH 3.0.

Feed or substrate materials included Kraft edible lactose, acid whey supplied by Crowley Food, Inc., and deproteinized acid whey (ultrafiltrate permeate), also supplied by Crowley. The edible lactose feed solutions contained Zepharin Chloride, a quaternary amine, at levels of less than 200 p.p.m. to prevent microbial growth.

The lactose content of whey feeds was determined by the Lane and Eynon (1) procedure (which uses Fehling's solution) for reducing sugars. Glucose concentration was measured using Worthington Glucostat.

In certain cases most of the salt was removed from the whey feeds prior to hydrolysis by ion exchange, using Rohm and Haas Amberlite IRA-93 and Diamond Shamrock Duolite C-25D ion exchange resins.

REACTOR STUDIES

Lactose and whey feeds, 5.0 and 3.3 to 4.0 percent lactose by weight respectively, were passed continuously through columns of 1.5 cm. diameter packed with 5 to 10 g. of IME. Columns were water-jacketed to maintain the desired temperature. Larger columns, including one 4 inches in diameter, containing about 6 lb. of IME, were also operated. Conditions of operation for specific studies are discussed in the subsequent sections.

IME KINETIC CONSTANTS

Kinetic constants K_m and K_i for the IME were found to be 0.0528 M and 0.0054 M respectively at 40°C., as shown in Figures 1 and 2.

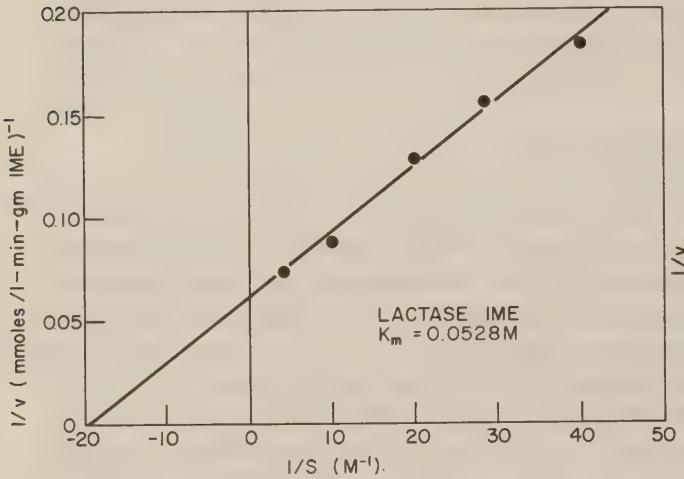


Figure 1.--Lineweaver-Burk plot.

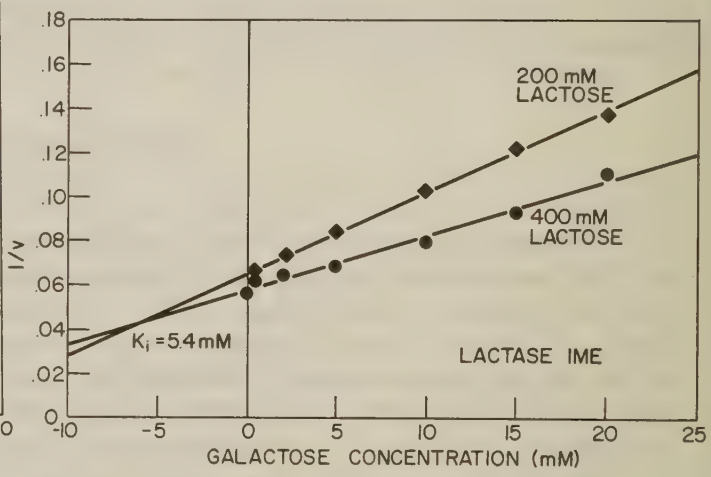


Figure 2.--Galactose inhibition.

RATE EQUATION

A theoretical curve relating conversion to normalized residence time (IME activity/flow rate) was calculated from equation (2) using the experimentally determined K_m and K_i values (k = 0.06 when F has units of ml./hr.). Experimental data from column operation agreed closely with the theoretical curve as shown in Figure 3. Thus, given conversion and flow rate, equation (2) could be used to obtain activity for monitoring column performance.

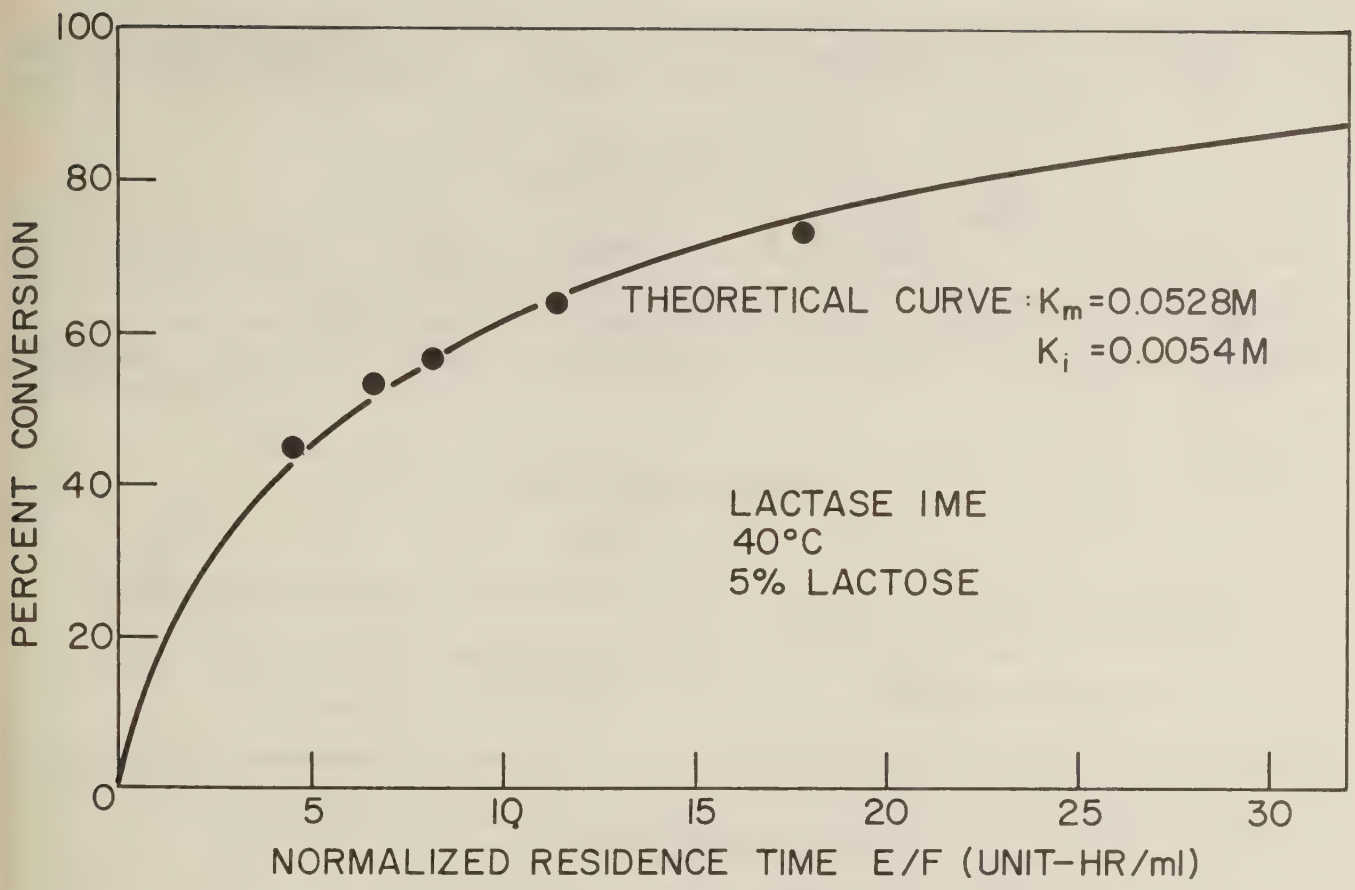


Figure 3.--Experimental data from column operation plotted on theoretical curve relating conversion to normalized residence time.

pH OPTIMA

The variation in enzyme activity, from initial rate determinations, as a function of pH for soluble and immobilized lactase is shown in Figure 4. Soluble lactase data is from Weetall et al (10). Enzyme immobilization shifted the pH optimum downward from 4.5 to the 3.0 to 3.5 range.

ACTIVATION ENERGY

The variation of reaction rate with temperature is shown in Figure 5. The activation energy was calculated to be 12.0 kcal./g.-mole (9.6 to 14.3 kcal./g.-mole 95 percent confidence limits). Weetall et al (10) reported an activation energy of 7.8 kcal./g.-mole for lactase IME. Assuming the reaction rate in that case to have been entirely diffusion controlled, the apparent activation energy should have been equal to half the intrinsic activation energy plus 1 or 2 kcal./g.-mole for diffusivity effects. The 7.8 kcal./g.-mole apparent activation energy is consistent with an intrinsic activation energy of 13 or 14 kcal./g.-mole or less. This fact, coupled with the straight-line plot in Figure 5, indicates the absence of significant pore diffusion effects in this study.

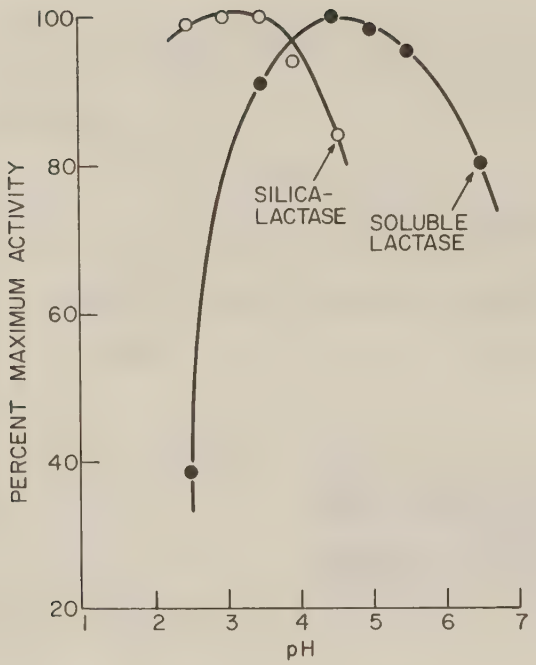


Figure 4.--pH optima.

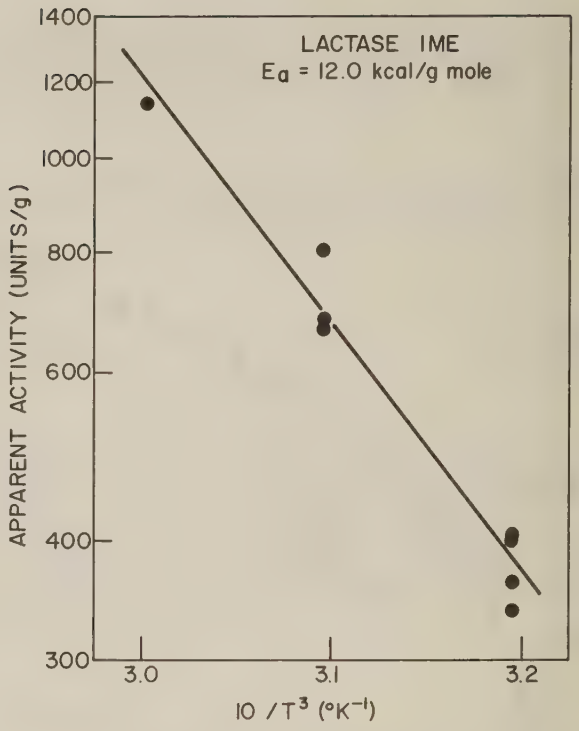


Figure 5.--Arrhenius plot.

MASS TRANSFER STUDIES

Internal mass transfer or pore diffusion limitations appear to be minimal, at least up to 60°C. with the 400 units/g. (40°C.) IME, from the reaction rate versus reciprocal temperature argument invoked in the preceding section.

External mass transfer or film diffusion effects were evaluated by operating columns containing IME beds ranging from 6 cm. to 71 cm. in height. These reactors were operated with the same normalized residence times and resulted in identical conversion levels. The tenfold increase in linear velocity evidently did not affect the conversion rate, implying that external mass transfer limitations were negligible.

Potential effects of backmixing can be estimated from a dispersion coefficient calculation described by Levenspiel (4). The dispersion number is defined as D/uL where D is the dispersion coefficient, u is the fluid velocity, and L is the bed height. This dispersion number can be related to the Peclet number,

$$N_{Pe} = \frac{ud_p}{D\varepsilon}$$

where d_p = particle diameter and ε = bed void fraction, by

$$\frac{D}{uL} = (N_{Pe})^{-1} \frac{d_p}{\varepsilon L} \qquad (3)$$

At Reynolds numbers less than 10 in a packed bed, the Peclet number is approximately equal to 0.5. For even a small packed bed, 6 cm. in height containing 30/45 mesh particles (.46 mm. diameter) with $\varepsilon = 0.35$,

$$\frac{D}{uL} = \left(\frac{1}{0.5}\right) \frac{.046}{(35)\ (6)} = 0.044.$$

From a graph given by Levenspiel for first-order kinetics (as an approximation, actual kinetics should be less sensitive to backmixing), the difference between real and ideal reactor volumes at 80 percent conversion is less than 8 percent. At lower conversions or greater bed heights the difference becomes even smaller.

COUPLING EFFICIENCY

Coupling efficiency, defined as

$$\frac{E_{IME}}{E_{initial} - E_{recovered}} \qquad (4)$$

where E is enzyme activity, is the percentage of enzyme not recovered from the enzyme solution after attachment, that is observed as active immobilized enzyme. In Figure 6 the relationship between coupling efficiency and amount of enzyme offered is shown for silica and titania carriers, with a reference point for zirconia-coated controlled pore glass (CPG). Much of the difference between the two carriers results from the higher surface area of the silica. In general, the higher the enzyme loading the lower the coupling efficiency. For cases where the enzyme is relatively expensive, it is important to obtain high coupling efficiency even at the expense of total loading.

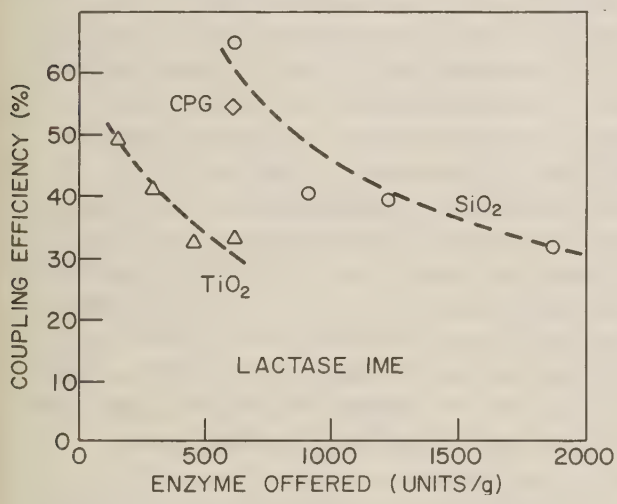


Figure 6.--Coupling efficiency as a function of enzyme offered.

HALF-LIFE STUDIES

One of the most important and most time-consuming properties of an IME system to measure is its long-term operational stability. Since this system, like many others, exhibits exponential activity decay, durability is expressed in terms of half-life, or the number of days required for the activity to fall to one-half its initial value. Figure 7 is an example of this type of data which falls in a straight line on a semilogarithmic plot. Half-lives were calculated from a linear regression of the log of activity versus time.

Two important variables were found to affect the observed half-life for an IME system: feed composition and temperature. From the following figures, it can be seen that the higher the purity of the feed, the longer the half-life:

Feed	Average half-life at 50°C. (days)
Whole acid whey	8
Deproteinized acid whey	10
5% lactose w/0.5% NaCl	13
Deionized, deproteinized acid whey	60
5% lactose	100

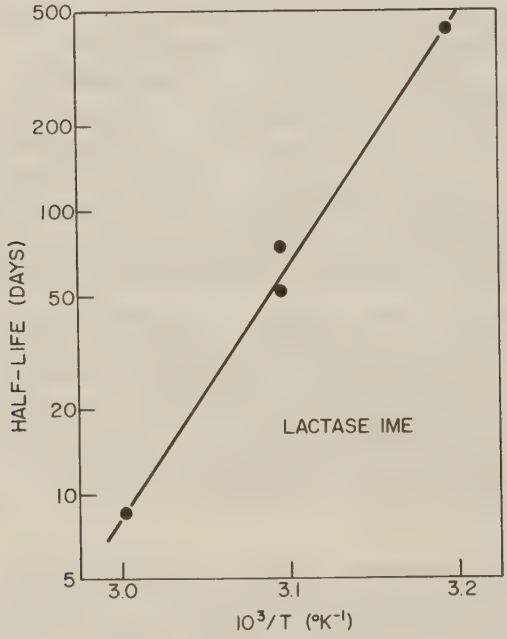


Figure 8.--Half-life as a function of temperature.

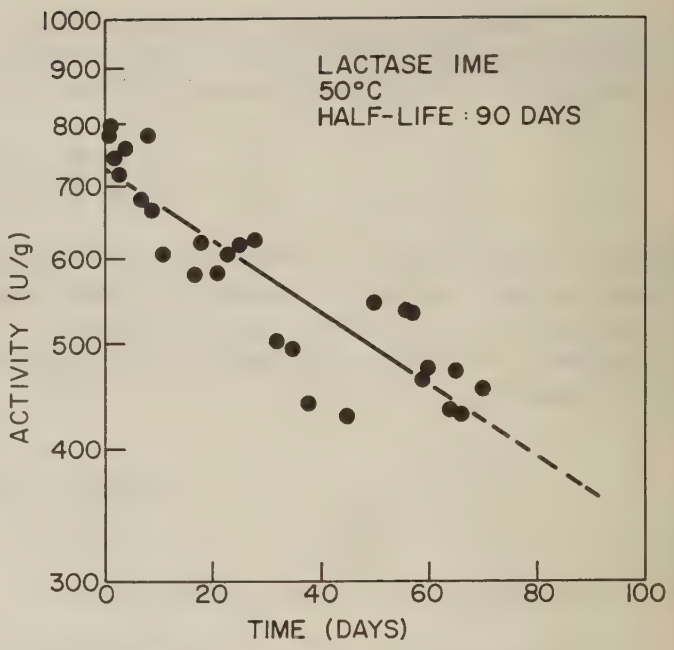


Figure 7.--Activity as a function of time.

The normal salt content of the whey feed was detrimental to enzyme half-life, although it affected activity insignificantly. Removal of 90 to 95 percent of the salt in deproteinized acid whey resulted in dramatically improved enzyme stability. From the effect of NaCl in lactose on enzyme stability, it would appear that the ionic strength of the salt plays an important role in decreasing enzyme life. Some of the difference between the results for ion-exchanged, deproteinized acid whey and lactose may have been due to physical attrition from the daily backflushing in the former case.

The effect of temperature on half-life is shown in Figure 8 with a deactivation energy 40.6 kcal./g. mole.

COLUMN BACKFLUSHING

In order to prevent microbial growth in the IME beds where whey feeds were used, the columns were backflushed (fluidized) with distilled water and brought to pH 4.0 with acetic acid. Columns were backflushed once daily for about one-half hour. No visible growths have appeared in columns operated in this manner for over a month.

REACTOR SCALE UP

A four-inch diameter column reactor containing a 28-inch deep bed of IME was operated at 38°C. Activity was calculated at 380 units/g. (at 38°C.) equivalent to 400 units/g. at 40°C., identical to the activity normally observed for laboratory scale columns.

Pressure drop, one remaining concern for additional scale-up, can be estimated from Leva's correlation as given by Perry (6).

$$\Delta P = \frac{2 f_m G^2 L (1-\varepsilon)^{3-n}}{\rho d_p g_c \phi_s^{3-n} \varepsilon^3} \qquad (5)$$

where ΔP = pressure (lb.-force/ft.^{2}); L = bed depth (ft.); G = fluid superficial mass velocity (lb./sec.-ft.^{2}); $f_m = 100/N'_{Re} = 100\ \mu/d_p G$ (for $N_{Re} < 10$), ε = void fraction; n = 1 (for $N_{Re} < 10$), d_p = particle diameter (ft.); g_c = 32.17 (lb.-ft./lb. force-sec.^{2}); ϕ_s = shape factor (0.95 for spherical sand), μ = viscosity, ρ = fluid density (lb./ft.^{3}), and N_{Re} = Reynolds number.

For the case of a tenfold deep IME bed at 35°C. and 50 percent hydrolysis a pressure drop of about 75 p.s.i. was calculated. For a six-foot high column under identical conditions, a pressure drop of about 27 p.s.i. is predicted.

PRELIMINARY SYSTEM DESIGN

In order to make a preliminary cost estimate for the hydrolysis of deproteinized acid whey, a plant design as shown in Figure 9 was developed. This flow sheet includes ion exchange and concentration equipment which will be discussed independently. The sizes for the hydrolysis system were based on use of lactase IME with an apparent activity of 300 units/g. at 35°C. An example of equipment cost estimates is given in Table I.

The projected operating conditions were set somewhat arbitrarily with an initial reactor temperature of 35°C. raised as necessary to maintain the initial conversion level until 50°C. was reached. From a half-life of 62 days at 50°C. determined experimentally for deproteinized, de-ashed acid whey and a deactivation energy of 40.6 kcal./g.-mole, the time required for the 35 to 50°C. cycle was calculated at 559 days. The number of pounds of lactose processed per pound IME was then calculated from the cycle time and reactor size.

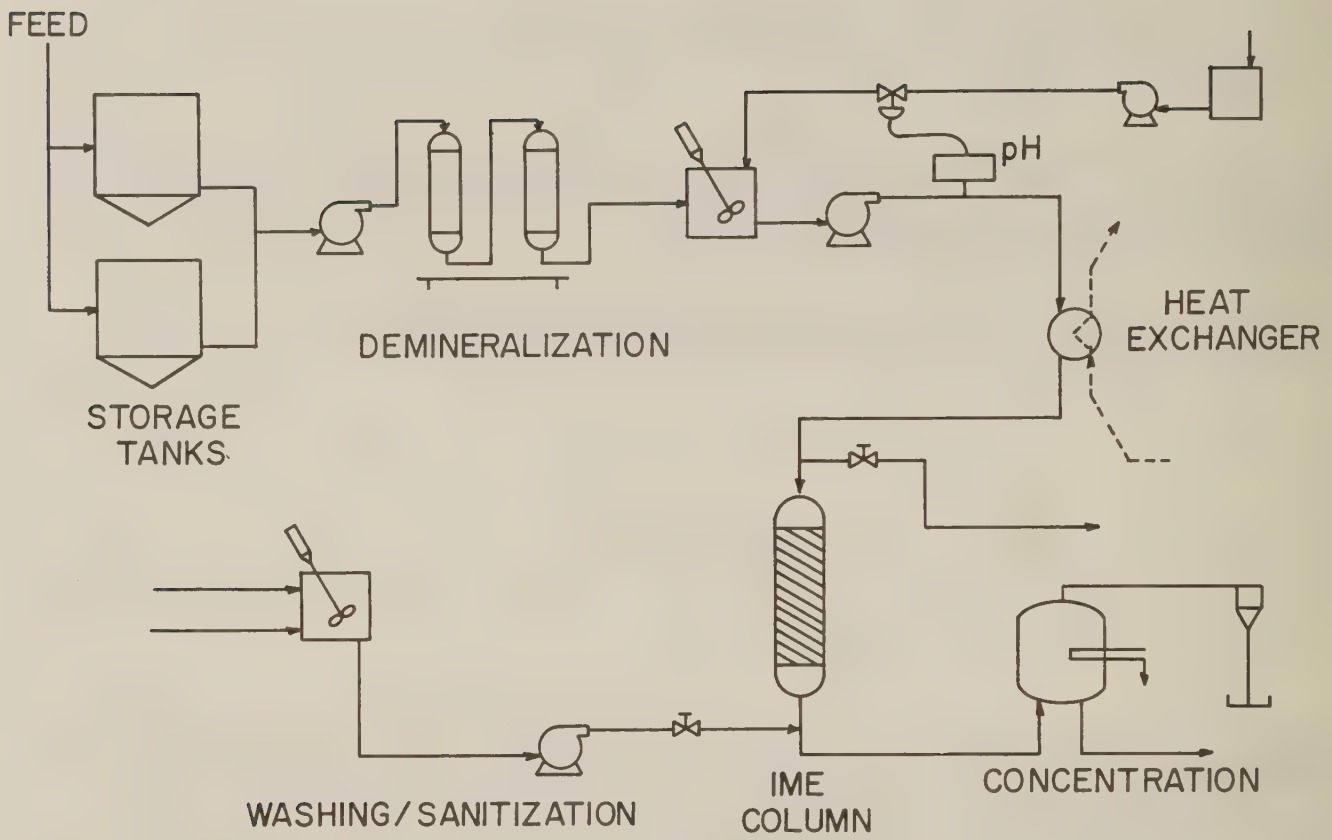


Figure 9.--Process flow sheet.

TABLE I.--Equipment cost estimate

Equipment (10,000 lb./day lactose, 50% hydrolysis)	No.	Cost	Cost ratio	Plant cost
Column	1	$ 4,300	4.0	$ 17,200
Storage tanks (12,500 gal.)	2	18,000	2.0	36,000
Process tanks				
100 gal.	1	400	2.0	800
300 gal. (w/agitator)	1	1,300	4.1	5,330
Pumps				
Centrifugal (20 gpm)	3	2,400	8.0	19,200
Metering	1	600	7.0	4,200
Heat exchanger	1	1,500	4.8	7,200
Instruments		4,000	4.0	16,000
				$105,930
Contingency (10%)				10,590
Total				$116,520

Processing costs included labor and supplies cost as shown in Table II, capital or equipment costs taken at 20 percent annually (included

TABLE II.--Operating cost estimate

Labor	(man-hr./day)	
Backflushing	3	
Monitoring	3	
Laboratory	2	
	8 @ $4.50/hr. =	$ 36.00
Supervisor	3 @ $6.00/hr. =	18.00
		$ 54.00
Overhead and fringes		54.00
Supplies (Acid, etc.)		20.00
Cooling costs		3.00
		$131.00
Cost per lb. lactose (10,000 lb. lactose/day)		1.3¢

depreciation, maintenance, taxes, etc.) and IME cost. Total costs are reflected in Figures 10, 11, and 12. This total cost does not include the cost of de-ashing or concentration and assumes the cost of deproteinized whey to be zero.

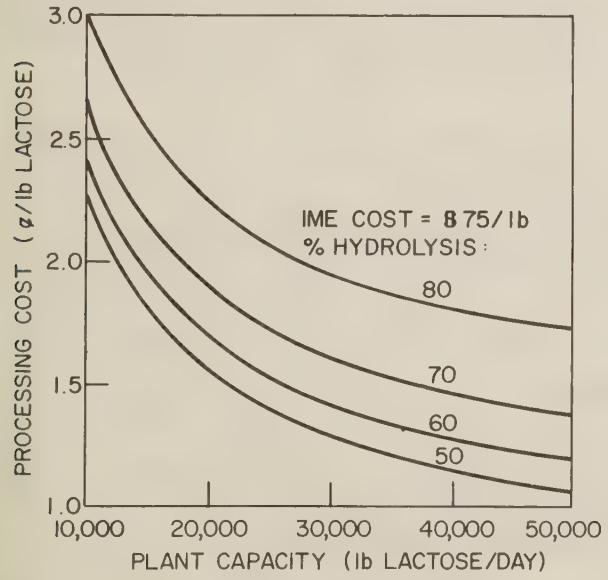


Figure 10.--Processing cost as a function of plant capacity.

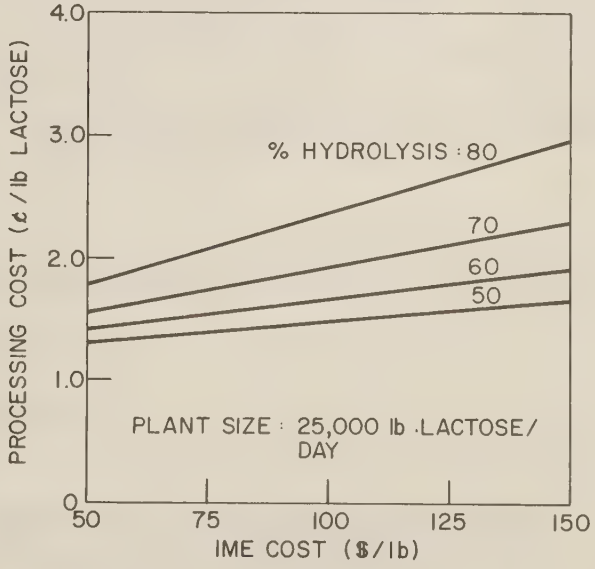


Figure 11.--Processing cost as a function of IME cost.

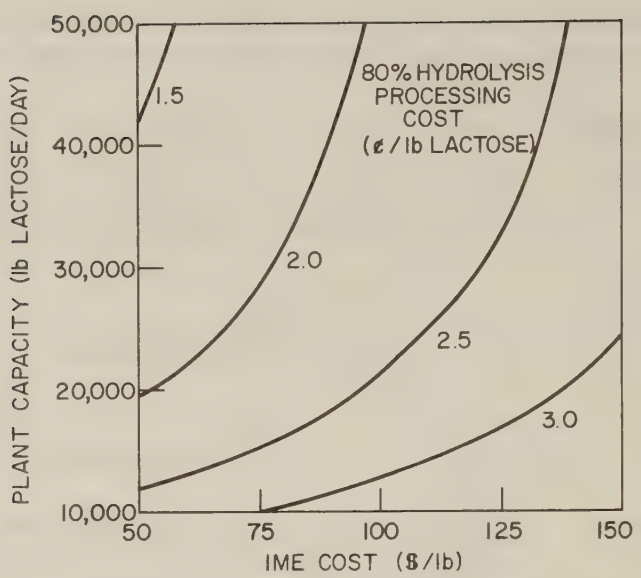


Figure 12.--Processing cost as a function of IME cost and plant capacity.

Processing costs appear to lie in the 1-to-4-cent-per-pound lactose range depending on plant size, IME cost, and percent hydrolysis. Figure 10 shows the dependence of processing cost on plant size at various hydrolysis levels. The effect of IME cost on processing cost is shown in Figure 11. Higher hydrolysis levels obviously are more sensitive to IME costs. Figure 12 shows processing cost as a function of plant size and IME cost. This type of plot can be useful for determining what IME cost must be achieved to meet given capacity and cost objectives.

Reduction in salt level prior to hydrolysis by ion exchange or electrodialysis results in a projected cost in the 2-to-5-cent-per-pound range including capital costs comparable to those for the hydrolysis system. Electrodialysis appears slightly more favorable economically at this point, perhaps costing in the vicinity of three cents per pound of lactose for 90 percent salt removal. Similar additional costs will be encountered for concentrating the product from 5 percent solids to the 50 percent or higher solids level necessary for sweetener substitution.

Overall costs of 8 to 10 cents per pound including royalties compare favorably to the current 15-cent-per-pound (dry basis) price for corn syrups (3).

ACKNOWLEDGMENTS

The authors gratefully acknowledge the technical assistance of Mr. R. E. Lindner and Mrs. L. F. Bialousz of Corning Glass Works.

LITERATURE CITED

(1) Anon.

1968. Standard analytical methods of the member companies of the Corn Refiners Association, First Revision, E-26.

(2) Charles, M., Coughlin, R. W., Allen, B. R., Paruchuri, E. K., and Hasselberger, F. X.

1973. Paper 17b, presented at 66th Annual Meeting, American Institute of Chemical Engineers, Philadelphia.

(3) Chemical Marketing Reporter.

1974. September.

(4) Levenspiel, O.

1962. Chemical Reaction Engineering, John Wiley, New York.

(5) Olson, A. C., and Stanley, W. L.

1973. J. Agr. Food Chem. 21: 440.

(6) Perry, J. H.

1963. Chemical Engineers' Handbook, 4th ed., McGraw-Hill, New York.

(7) Pitcher, W. H., Jr.

1974. Dairy Scope, 18 (March).

(8) Stanley, W. L., and Palter, R.

1973. Biotechnol. Bioeng. 15: 597.

(9) Weetall, H. H., Havewala, N. B., Pitcher, W. H., Jr., Detar, C. C., Vann, W. P., and Yaverbaum, S.

1974. Biotechnol. Bioeng. 16: 295.

(10) Weetall, H. H., Havewala, N. B., Pitcher, W. H., Jr., Detar, C. C., Vann, W. P., and Yaverbaum, S.

1974. Biotechnol. Bioeng. 16: 689.

(11) Weetall, H. H., and Havewala, N. B.

1972. In Enzyme Engineering, L. B. Wingard, Jr., ed., p. 249, John Wiley, New York.

WHEY IN CHOCOLATE CONFECTIONS

R. T. O'CONNELL

Chocolate Manufacturers Association of the U.S.
McLean, VA 22101

Confectioners have used whey for a number of years in caramels and some other candy products, but not in chocolates. Whey is prohibited in chocolate because it is not an optional ingredient within the chocolate standards.

About a year ago Jack Walsh, Executive Director of the Whey Products Institute, and Jerry Hutton of Foremost Foods came to visit us in Washington to talk about the possibilities of whey as an optional ingredient in chocolate. We looked at it two ways. One, whey as a substitute for some milk solids or two, as a substitute for sucrose. We were concerned, actually a little fearful, about getting into whey because of the lactose intolerance we had heard about. Chocolate is a product sold strictly for the pleasure it gives to the person eating it. Its flavor and its "feel in the mouth" are its primary selling points. So we have to be very careful in making any changes in the formulas for chocolate. Only one or two poor-tasting samples can be enough to discourage the consumer from buying chocolates. So we are very conservative about making any changes in the chocolate formula--the recipe, so to speak--which might affect the flavor.

But after further discussion with Jack and with the Foremost people, we decided to look at three types of whey, a partially demineralized whey, a demineralized whey and a whey protein concentrate. This summer we had Foremost send samples of these whey products to the chairman of what we call our cocoa bean evaluation committee. This is a group that takes cocoa beans from various sources, mixes them with milk, sugar, etc., in various proportions and then submits them to taste panels within our member companies.

Since whey was new to us, we took a very basic formula. (Each of the companies, as you might suspect, uses different formulas based on the consumer acceptance of its product.) We used 12-1/2 percent chocolate liquor, 18 percent whole milk solids, 21 percent cocoa butter, and 48 percent sugar. We used lecithin as an emulsifier and vanillin for taste purposes.

We reduced the 48 percent sugar to 35 percent and substituted the whey for 13 percent of the batch weight. When we thus replaced part of the sugar in the formula with whey we found an interesting result that has nothing to do with the quality of the product. Less chocolate liquor is needed. The chocolate liquor results from grinding the cocoa bean into what are called nibs, and then grinding the nibs under further pressure until they are liquefied. This

chocolate liquor is the basic ingredient of chocolate confections. We found that by replacing some of the sugar with whey we can reduce the amount of chocolate liquor from 12-1/2 percent batch weight to roughly 10 percent. That may not sound like much, but we use a quarter of a million tons of cocoa beans in the United States annually. It takes 125 pounds of beans to get 100 pounds of chocolate liquor. That is almost a 20 percent saving, maybe a little more. Yesterday Ghana cocoa beans were priced in New York at $1.03. Cocoa butter is two and one-half times that, or roughly $2.50 a pound. At these prices a 20-percent substitution represents a substantial saving. Of course, these prices are not average; they are triple what they were a year ago. But even if the price of cocoa beans were only 40 cents, the savings would still be appreciable. This potential saving in chocolate liquor was a completely accidental finding. It had nothing at all to do with our original intention, which was simply to learn whether whey could be substituted for some of the sugar without changing the flavor and texture of chocolate.

Our next step is to consider the whey as a milk substitute. We don't know yet whether this can be done. In another year, or even in another six months, we may be able to report on this to the Whey Products Institute.

The next step after that, of course, would concern the standards, which we have been discussing in great detail. The Food and Drug Administration is changing views on rigid recipes and standards and is favoring a more general approach. These are new developments in the chocolate industry.

At the present high prices of cocoa beans, sugar, and milk, whey derivatives look fairly promising as substitutes in chocolate formulas. What we don't know at this time--and what the success of the substitutions will hinge on, regardless of the economic advantages--is the effect of the whey on flavor.

As the climax of his presentation, Mr. O'Connell announced he had brought with him samples of the first chocolate bars to be made containing 13 percent whey as a replacement for sugar. He said they had not yet been tasted by members of his evaluation committee, nor had he tasted them himself. Although he said 10 members make up the usual taste panel--all of them expert tasters--he selected five members of the audience to make a fair test of the samples from the standpoint of the untrained consumer. To serve on this "consumer panel" he selected Mr. Lee Boyd, American Feed Manufacturers Association; Mr. Richard Schneider and Mr. Richard Melacouras, Stauffer Chemical Company; Mr. Donald Proctor, of Foremost Foods Company and president of the Whey Products Institute; and Dr. B. J. Demott, of the University of Tennessee. The tasters were instructed to take a drink of water before tasting each of three samples of chocolate, numbered 1, 2, and 3. They were to eat each sample slowly, allowing it to get to the roofs of their mouths before swallowing it. They were to assign the three samples a rating on the basis of taste, sweetness, chocolate flavor, and especially the presence of any granulation or breaking down of

the sugar crystals. Before announcing which sample was which, Mr. O'Connell asked the panelists to indicate their ratings. They were as follows:

MR. BOYD: 1, 3, 2

MR. SCHNEIDER: 1, 3, 2

MR. MELACOURAS: 3, 2, 1

MR. PROCTOR: 1, 3, 2

DR. DEMOTT: 1 preferred, 2 and 3 equal

Thus sample 1 was preferred by 4 out of the 5 panelists. Both samples 1 and 2 were made with 13 percent whey. The whey used in sample 1 was 25 percent demineralized (Nutritec 250) and that used in sample 2 was 90 percent demineralized (Nutritec 900). Sample 3 was the control made with the standard chocolate formula and without any replacement with whey.

We are encouraged that in this maiden test--made admittedly with only a few tasters and certainly not a trained panel--80 percent showed a preference for one of the samples containing whey. Even if all the panelists had preferred sample 3, the control, I think I would have continued our work. But it certainly would not have given us such an encouraging start as this has. By itself, this little test is not much to go on, but it encourages us to keep looking for new opportunities for the use of whey in chocolate.

WHEY-SOY DRINK IN OVERSEAS PROGRAMS

BARBARA FELTON

Food for Peace, AID, Department of State
Washington, DC 50523

As you are aware, a new whey-based beverage--whey-soy drink mix--has been developed during the past year for distribution overseas in the Food for Peace Program. Food for Peace, or Public Law 480, came into existence in 1954. Since that time over 217 million tons of food has been shipped overseas, 181 million tons under the Title I sales program and 36 million tons under the Title II donation program.

The whey-soy drink (WSD) mix was developed for use primarily in the Title II donation program and more specifically for use in child feeding programs. AID's highest priority is what we call "maternal child health" (MCH) programs. Nutritionists agree that the most critically malnourished people in lesser developed countries are children between the weaning stages and 5 years old as well as pregnant and lactating mothers. It is our goal--and by "our" I mean not only Food for Peace, but AID, voluntary agencies and the World Food Program--to strengthen maternal child feeding programs around the world. We are encouraging host governments that have not already done so to declare that it is their national policy to eradicate child malnutrition and infant mortality. By using Food for Peace commodities to support such MCH feeding programs and by working with the governments that participate in these programs, it is hoped that countries will eventually be able to do the job themselves. It is reassuring to note that many developing countries are devoting increased attention and resources to this problem and there is a growing awareness of the benefits of proper nutrition.

For those of you who may not be familiar with the whey-soy drink mix, it contains approximately 20 percent protein and provides roughly 2,100 calories per pound. An 8-ounce serving, which is the daily ration recommended by AID, provides approximately 7 grams of protein and 160 calories. For a-3-year-old, this is equal to 28 percent of his recommended daily dietary allotment for protein and 15 percent of that for calories.

The whey-soy drink mix was initially tested by the U.S. Army Natick Laboratories in 6 Food for Peace programs. The countries participating in the initial testing were Chile, India, Pakistan, Sierra Leone, Vietnam, and Dominican Republic. The countries selected included a variety of geographic areas and cultures.

The test data collected by Natick indicated a high degree of acceptability by the children fed.

In addition to field testing, WSD was tested by Dr. George Graham in Peru on malnourished children. He was impressed by the results of his tests. Product storage tests indicate that WSD has a shelf life sufficient to withstand high temperatures and humidity. All in all, testing has proved that WSD has a role to play in the Food for Peace program.

To date, over 4 million pounds of whey-soy drink mix has been purchased for ultimate distribution in eleven countries. Of this amount, 200,000 pounds were programmed into last fiscal year.

On the average, procurement has been about one million pounds a month. The supply of WSD has been moving well and we are happy to have several companies supplying this product.

In conclusion, WSD is filling a need in our overseas program. It is a food designed for the most susceptible victims of poor diet. This commodity is helping to attack the nutritional problems that have plagued the developing countries for so long.

WHEY IN MARGARINE PRODUCTS

L. H. WIEDERMANN

Swift and Company
Oak Brook, IL 60521

Margarine is a standardized food product, and as such is defined under "Standards of Identity." These standards restrict the kinds and amounts of its ingredients, and until their most recent revision, did not allow for any whey to be used in margarine products.

The revised standards, which allow the use of whey, do not as yet apply to all margarine products. Those margarine products which come under USDA inspection - and these are products formulated from animal fat as opposed to all vegetable oils - are still regulated by unrevised standards. Briefly, let me indicate the conflict.

Margarine began a century ago as an animal fat product. Thus the first regulatory laws (1906) considered it a meat food product subject to the usual meat inspection requirements of the Department of Agriculture.

After World War I, much of the margarine was manufactured only with vegetable oils, and the proportion of vegetable oil margarine has long since become much greater than that of the animal fat type. Vegetable margarine comes under regulation of the Food & Drug Administration. Therefore, FDA has been and is the regulating agency for most margarines. Since 1950, only 5 to 10 percent of the margarine produced comes under USDA inspection. Margarine is the only standardized food product so split in its regulation between two Federal agencies.

Margarine is defined under standards as an 80 percent fat product containing some specified optional ingredients such as salt, emulsifiers, color, and flavorings, and an aqueous phase. Our concern today is with this aqueous phase.

Both the old FDA and current USDA standards define the aqueous phase as either a cream, milk, skim milk, liquid sweet cream buttermilk, any combination of dry or condensed sweet cream buttermilk and water with a total solids content of not less than 8.5 percent and any combination of nonfat dry milk and water in which the weight of the nonfat dry milk is not less than 10 percent of the weight of water. The term milk in this instance means cow's milk. This does not include whey products. Additionally, finely ground soybeans and water in which the weight of ground soybeans is not less than 10 percent, is also allowed.

Late in 1973 the FDA reissued its margarine standards to conform more or less with the World Health Organization Codex Alimentarius Commission, a recommended international standard for margarine. The aqueous phase is now defined for all vegetable oil margarines, at least 90 percent of the margarines produced in this country, as "(1) Water and/or milk and/or milk products. (2) Suitable edible proteins including but not limited to whey, whey modified by the reduction of lactose and/or minerals, nonlactose containing whey components, albumin, casein, caseinate, vegetable proteins or soy protein isolate, in amounts not greater than reasonably required to accomplish the desired effect."

It is quite obvious that an industry that has been restricted by regulation from using whey and whey products would have little or no experience with their use. That is our current situation in the margarine industry. Our experience is very limited, some negative and some positive.

The margarine industry has traditionally used skim milk, first fluid and now reconstituted low-heat, nonfat dry milk solids. This practice, aside from meeting standards, provides the margarine with enhanced flavor characteristics and a proper curd when melted or drawn. The old standard required 10 percent solids basis aqueous phase or about 1.5 percent curd on a finished product basis. Under the new standards this level can be reduced by two-thirds to a 0.5 percent curd basis of finished margarine and still provide desirable flavor contributions. This reduced level significantly combats the pressures of rising nonfat dry milk powder cost and represents the target cost for alternate sources of proteins for the aqueous phase.

Whey as an alternate source of aqueous phase solids can be visualized as either straight whey powder, a modified whey or whey in combination with other milk or vegetable protein products. Whey as such - and this is admittedly based on limited experience - is a generally unsatisfactory basis for good flavor characteristics. Initially the margarine will have a very acceptable flavor, but on storage it can develop cheese-like flavor notes and/or atypical, incompatible flavor notes. I do not know of any experiences with modified or demineralized wheys. Whey in combination with other proteins, notably soybean protein, works very well. Since the first of the year one retail margarine product in national distribution has been using such an alternate protein system whose principal ingredient is whey.

In closing, I should like to make three points: (1) The basic suggestion that whey should be used in margarine products is largely untested and unproved. (2) The market for table-grade margarines is 1.5 to 2 billion pounds per year. At a 2-billion-pound level, margarine would require at least 10 million pounds of aqueous phase solids. (3) If whey products are used in margarine, they will have to be identified in the list of ingredients in a way that has an acceptable connotation to the consumer. While this last point focuses primarily on the consumer, we should not overlook the possibility the manufacturer would have of changing from one whey product to another without changing the declarations on the label.

Standing on the outside looking in, I would heartily endorse the suggestion Prof. Nickerson made earlier that it is up to the whey industry to provide the right products and then market these products effectively.

WHEY IN ANIMAL FEED

L. H. BOYD

American Feed Manufacturers Association
Arlington, VA 22209

It may or may not have been purposeful that I am last on the program. Perhaps if it was not purposeful, it could have been because the feed industry has been looked upon as a last resort, a solution to be considered after all other possible solutions have failed. In essence we might say that we have been categorized by some as a "dumping ground" for materials for which on one else could find a home. But this is a logical happening.

Our industry has a long history of by-product usage. One article reports that the by-products of wheat milling, the bran and the middlings, were once dumped into the rivers because no one knew what else to do with them. Then, in an attempt to find another outlet for them, somebody discovered they gave beneficial results if put into the diets of animals, and we were off and running. We now use a very wide variety of by-products. We are built basically on by-product usage.

As a matter of fact, the feed industry is now utilizing hydrolyzed poultry feathers and comparable products in feeding animals. The feed industry could almost be compared to a miniskirt. You wonder what it will be up to next.

Now ours is a large industry. It is among the top 20 manufacturing industries in the country. Our product, our basic manufactured feed, is being made, according to the best estimate I can give you, at the rate of about 60 million tons a year. That is not counting the secondary manufactured feed. If you included that, the total might be as high as 120 million tons. Nor does this figure count the silage and the pasture that may be fed on the farm. Sixty million tons represents just the primary manufactured product.

You can see immediately why a lot of people look at the feed industry as a possible solution if they wish to dispose of something. As for your 1.5 billion pounds of whey, we could get rid of 1.2 billion pounds, if my mathematics are correct, just by incorporating it into our 60 million tons at the rate of one percent. We could solve your problem very quickly. But there is a little more to incorporating it into the feed than just saying so.

Our industry is based on a scientific approach to animal feeding. We don't just throw things together and feed them to animals. As a matter of fact, we know more about nutrition of an animal than I believe will ever be known about the nutrition of a human. We can experiment with animals in ways that you can't very well with humans.

Last but not least, there are some very basic economic considerations in our industry. As you all recognize, food of animal origin competes with foods of other origins, and we have to be as efficient as possible in producing that food of animal origin. We have to utilize every bit of scientific input that we can.

My understanding from earlier presentations of this conference and from conversations with my friends in the business is that 1.5 billion pounds of whey solids are produced annually, of which about 800 million pounds is processed and about 700 million pounds is not -- which represents the attempts to utilize the quarry and the proportion valve in spreading it on asphalt surfaces and such. All-in-all, there is about half of it that is not processed which is a potential. With whey products it seems to me that there are two basic uses -- food and feed -- and of the two, the food uses should be more lucrative. If a substance can be used in both food and feed, obviously it should demand a better price as a food item.

Of the 800 million pounds that are processed, the best estimate is that about 400 million pounds goes into food and about 400 million pounds into feed. Of the 400 million pounds that goes into feed, I believe more than half is used for calf milk replacers, the veal-type formulas you have heard about; and, somewhat less than half goes into feeds for baby animals - mostly, I believe - baby pigs. These feeds we utilize to get baby pigs on solid feed just as soon as possible - and, I suppose, there is some usage in pet foods, although I have not been able to determine how much at this time.

Why are whey products currently being used in milk replacers? Basically, because skim milk -- or, if you prefer, nonfat dry milk -- is no longer available to us. We have had to turn to other milk products, and we turned to whey and products from whey.

For feed for a very young animal like a calf, a quality whey product is needed. You can't just take something that somebody says is unsuitable for food use. The animal nutritionist has to know what he is dealing with. He is interested in the nutrient content of the product and the availability of those nutrients, as well as the cost. He requires a product of known quality.

Now what is this market currently? What is its future? I am sure you are all familiar with the fact that dairy cow numbers have been declining as the production of each cow increased, a reflection of our need to be ever more efficient. Today, I would say that the market for milk replacers is relatively static for these reasons. The information I have seen indicates that cow numbers will continue to decline and production per cow will increase. I believe the average production today must be somewhere around 10,000 pounds of milk per cow. The predictions are that this production will ultimately be doubled, to 18,000 to 20,000 pounds. If that is the case, and the need for milk remains about the same, or perhaps slightly more because of population increases, we are still going to have fewer cows. Fewer cows means fewer calves and this to me means a somewhat limited market for milk replacers.

The value of a newborn calf on a dairy farm is falling to the point where the dairyman may not even bother to try to sell the animal, but will simply dispose of it. It is not worth his time to haul it to the sale barn. Under such

an economic condition, an immediate depression in the market for milk replacers is clearly in prospect.

How about baby animal feeds? I mentioned pig feeds. To make the pig as efficient as possible, we try to get the baby pig on solid feed just as soon as possible. We used to leave the baby pigs with the sow for five or six weeks. Now that time is cut in half. One way to get these baby pigs on solid feed earlier, and take them off the sow sooner, is to put before them a very palatable feed. The feed should be put next to the water in an area that is inaccessible to the sow so that the little fellows are encouraged to eat. The quicker you get them on solid feed, the quicker they begin to gain, and the better they do. One way of increasing the palatability is to use sugar. We used to incorporate sugar at the rate of 10 percent in the baby pig feed. Another way is to use high-quality ingredients like whey products. The baby pig feed market, however, like that for the calf milk replacer, is somewhat static in that the consumer demand for pork seems to be relatively stable.

The number of pigs we raise in this country per year falls within narrow limits. The numbers will go up, of course, as our population increases and we need more pork for that increased population. So, here is a market, but I think it is pretty well satisfied at this time.

What about other possibilities? Well, of the two forms in which we produce feeds, dry and liquid, the liquid fraction of our industry has been rapidly growing. Liquid supplements are used for dairy cattle and beef cattle. Sometimes they are fed as liquids, sometimes they are mixed with dry material prior to feeding. There are some whey products that are being utilized in liquid supplements, and the area has a potential.

Whether the feed is liquid or dry, the animal nutritionist, the one who is putting together the formula, has certain needs. The purchasing agent also has certain needs for information. I would like to discuss these needs with you for a minute.

Offered a material that might be a potential feed ingredient, the nutritionist first needs a nutrient profile of that material. He needs to know what it contains in the way of nutrients. As I indicated, we know more about the nutrition of an animal than we do about the nutrition of a human. We are able to experiemnt. I am not saying our information is complete, but we do know more.

In essence, the nutritionist tries to develop a feed formula that will provide the nutrient needs of the animal. The animals are not given a choice. The feed is put in front of them. Unlike the producer of food for human consumption, whose products compete with others in the marketplace for people's acceptance, we are producing the complete ration. We balance requirements with what is available in the way of nutrient sources to put together a formula to meet the known needs of the animal.

Now the needs of the animal are not static. The needs for maintenance, for example, are not the same as those for maximum rate of production. The feed placed before the animal must meet the nutrient requirements for whatever the animal is expected to do.

First of all, the nutritionist obviously needs a nutrient profile of the available feed ingredient. He can then judge it, see if it is rich in certain things he needs, and recognize its deficiencies. He needs to know the availability of the nutrients. Nutrients that may be present in the feed but are not available to the animal that consumes it don't do one bit of good. The nutritionist must also know what there is in an ingredient that would enhance its desirability as a nutrient source for the animal.

Now as I said, our knowledge of animal nutrition is not complete. We know, for instance, that incorporating into a poultry diet a given amount of certain ingredients will make the chick grow a little more rapidly. We don't know why. Some day we probably will. We can experiment, and get the answer to that question. In the meantime, we can take advantage of knowledge that there is a factor in some ingredients that enhances their worth. To do so, the nutritionist needs to know this factor exists. The nutritionist also needs to know if there are any limiting components, as has been mentioned. For example, excessive lactose may cause a problem in some animal diets.

The nutritionist also has to work hand-in-hand with the purchasing agent. An ingredient with the greatest possible potential that is not available in sufficient quantities, not available on a routine basis, not known for sure to be available at all times, or available only at an unknown or unreasonable cost cannot safely be included in a feed formula.

Formulas used to be figured with paper and pencil. Now all the pertinent information is put into a computer, which selects the most nutritious, economical, and practical feed to use. When computers were first put to this use, one of the major feed manufacturers tried it for the selection of a broiler feed. The nutrient requirements of the broiler and the nutrient content of the various feed ingredients available and the cost of each were plugged into the computer. The feed formula the computer came up with was essentially hydrolyzed feather meal and corn meal, plus some supplementation to compensate for the limited amino acid profile of feather meal.

They laughed and laughed at the stupid machine. They tried the feed on an extra pen of birds to prove the formula wouldn't work. Lo and behold, the feed performed beautifully. They then thought they had a world-beater broiler feed formula until their purchasing agent called them up short. He reminded them that if they went to that type of formula they would essentially have to corner the supplies of feather meal available to the feed industry. This would run up the price to the point where the formula would no longer be the most economical. Consquently, they had to back off.

This illustrates the need for the nutritionist to work hand-in-hand with the purchasing agent. The purchasing agent is primarily concerned with quality, service, and price. He has to buy the materials needed at a given quality standard. The feed industry cannot be a true dumping ground. We can utilize a wide variety of materials and a variety of quality, but when it comes right down to it, when the formula is put together, the quality of each ingredient has to be known. The purchasing agent must be able to buy material of a given quality. He also has to be able to get it when he needs it. Feed mills today are literally mixing stations. They don't carry big inventories. The purchasing agent has to know when each ingredient is available and if there are any periods of

time it won't be available. He also has to know approximately what he can expect it to cost.

With this information, he and the nutritionist can work together to produce a feed that will give the maximum possible results at the minimum cost when fed to an animal. Economics does play a very important part in the overall picture.

Basically, our feed industry is providing a corn-soy type of diet for animals. Corn and comparable grains are our major energy sources. Soy is our major protein source. To be sure, we use other things like cottonseed meal, by-products from the rendering industry, and so forth. But corn and soy are the basis of our animal diet. And the question is, "Can the product you offer us compete on a nutrient basis, and on a cost basis, with what we already have available? If you are going to supply us with a product that is basically energy in its nature, how will it compete with corn? If it is basically a protein source, how will it compete with soy?"

As I understand it, when corn was $1 or $2 a bushel, whey products had no chance of competing as an energy source. Now that corn is around $3.50 a bushel, perhaps getting up to $4 a bushel, there may be a possibility.

If you are going to sell us protein, it is either going to have to be competitive with soy or you are going to have to supply us with an amino acid make-up that enhances its value to us.

Now what have you got to offer? I don't know. But you should know your product. I think that has been alluded to by the previous speakers. You should know your product before you come to us. At least you should know enough about it to be able to tell us what is in it.

To find out whether or not you have a potential market, talk to several good feed-industry nutritionists or purchasing agents and ask what interest they may have in your product. This is the true test.

We are always interested in looking at new products, new sources of nutrients. But as I indicated, they have to be competitive in the marketplace with what we are already using, and we do use a wide variety of ingredients.

QUESTION: My question is this, Mr. Boyd, as a result of delactosing and then demineralization we have what we call effluent. Do you foresee any potential use within the animal feed industry for these mineral salts?

MR. BOYD: I am not really in a position to answer that question. I can only say broadly, if you have something you feel we might make use of, certainly put it in front of us and let our nutritionists see if it can be utilized. It comes down again to what is contained in the substance and if the cost is competitive. If it is not competitive, you can't expect us to use it.

Essentially in animal feed, as contrasted somewhat to human food, the source of the nutrient is not important to us, all other things being equal. What we are interested in is the nutrient content of the material and as I said, of course, the availability of the nutrients to the animal. But the source does not

make much difference to us. We use corn and soybean meal, hydrolyzed poultry feathers and animal by-products. We can use almost anything. What we do is make a scientific judgment as to what nutrients are in a given material and how much they cost. This is our criteria.

QUESTION: Do we know how young pigs perceive the relative sweetness of different sugars?

MR. BOYD: I do not know that. We have not gone into anything like that. They tell me a pig has a sweet tooth, much as humans. We were putting sugar into the feed for very young pigs; we experimented with coating the pellets with the sugar. The pig would be curious and pick it up. If the pellets had a sweet taste he would munch away. We found later we could simply incorporate the sugar in the total make up of the ration so that it was distributed throughout the pellet. We simply use sugar as a tool to get the pig eating. As soon as we get the pigs eating, we take the sugar out of the formula, because it is one of the most expensive components.

QUESTION: Mr. Boyd, have you run any tests in regard to diarrhea in feeding excessive quantities of lactose?

MR. BOYD: I would point out I am not actively engaged in research or formulating feeds. I don't know the answer. However, it is my understanding that this is what you run into in poultry. Lactose intolerance is one of the things that would be included in an ingredient profile. Such a profile should consider not only the abailability of the nutrients but other factors, some of which enhance the value of a feed ingredient and others detract from it. There are such factors as lactose intolerance that limit the use of certain ingredients in feeds.